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ART. XXVIII.—*On certain parallel relations between the classes of Vertebrates, and on the bearing of these relations on the question of the distinctive features of the Reptilian Birds;* by JAMES D. DANA.

AT the close of an article by Prof. Hitchcock, in this volume (p. 57), a portion of a letter of the writer is quoted, in which a parallelism is drawn between the Oötocoid or semi-oviparous Mammals (*Marsupials* and *Monotremes*), the Ichthyoid Reptiles (*Amphibians* of DeBlainville, *Batrachians* of many authors), and the Reptilian Birds. The general fact of this parallelism throws light on (1) the classification of Mammals, (2) the distinctive features of the Reptilian birds, and (3) the geological progress of life.

1. *Classification.*—The Amphibians are made by many zoologists an independent class of Vertebrates, on the ground of the fish-like characteristics of their young. The same systematists, however, leave the Marsupials in the class of Mammals, notwithstanding their divergencies from that type. The number of classes of Vertebrates, usually regarded as four, thus becomes *five*, namely, Mammals, Birds, Reptiles, Amphibians and Fishes. There are some indications that this number will soon be further increased by some zoologists, through the making of another class out of the *Reptilian Birds.*[1]

[1] Professor Agassiz, in vol. i of his *Contributions to the Natural History of the United States*, page 187, subdivides Fishes into four *classes*, namely, 1, Myzonts; 2, Fishes proper, or Teliosts (Ctenoids and Cycloids); 3, Ganoids; 4, Selachians; which would make the total number of classes of Vertebrates *nine*.

The discovery of the Reptilian Birds has brought the general law to view, that, among the four classes of Vertebrates, ordinarily received, each, excepting the lowest, consists of, *first*, a grand *typical* division, embracing the majority of its species, and *secondly*, an inferior or *hemitypic* division, intermediate between the typical and the class or classes below.

Before proceeding with our illustrations of this point, a word may be added in behalf of these four classes. In order to appreciate their true value, it is necessary to have in view the *type-idea* which is the basis of the fundamental characteristics of each, and which is connected with the existence of *three* distinct habitats for life—the water, the air, and the land: that in Fishes, this idea is that of *swimming aquatic* life; in Reptiles, that of *creeping terrestrial* life; in Birds, that of *flying aerial* life; in Mammals, that of *terrestrial* life, again, but in connection with a higher grade of structure, the Mammalian. The type-idea is expressed in the adults both of the typical and hemitypic groups; and any attempt to elevate the hemitypic into a separate class tends to obscure these ideal relations of the groups in the natural system of Vertebrates.

The following are the illustrations of the law above mentioned.

(1.) In the classification of Vertebrates, Mammals, the first class, are followed by Birds, as the second; and while the former are viviparous, the latter are, without exception, *oviparous*. The species of the inferior or hemitypic group of Mammals, partake, therefore, in some degree, of an *oviparous* nature, as the term *semi-oviparous* or *Oötocoid* implies.

In fact, all Vertebrates excepting Mammals are typically oviparous, although some cases of viviparous birth occur among both Reptiles and Fishes. In the viviparous Mammal, the embryo during its development derives nutriment directly from the body of the parent until birth, and also for a time after birth; while in the viviparous Fish, the Selachians excepted, there is simply a development of the egg internally, in the same manner, essentially, as when it takes place externally. Applying then the term oviparous to all cases in which the embryo is shut off from any kind of placental nutrition, Reptiles and Fishes, with the exception mentioned, are as essentially oviparous as Birds. Hence, the Oötocoids or non-typical Mammals are actually intermediate in this respect, and in others also, between the typical Mammals, on one side, and the inferior oviparous Vertebrates collectively, on the other.

(2.) Again, the class next below Birds is that of Reptiles. And, correspondingly, the inferior or hemitypic group of Birds is *Reptilian* in some points of structure.

(3.) Again, the class next below Reptiles is that of Fishes; and therefore the inferior or hemitypic group of Reptiles is the

intermediate or *Ichthyoid* one of Amphibians—the young of frogs and salamanders and other included species having gills like fishes, besides some additional fish-like peculiarities.

The parallelism between the three classes, Mammals, Birds and Reptiles, is thus complete.

(4.) Fishes have no class of Vertebrates below them, so that an *inferior* hemitypic division is not to be looked for. It might be suspected that the intermediate group in this case would be one between Fishes and the lower subkingdoms either of Mollusks or of Articulates; but none such exists. The lowest fish, an Amphioxus, is as distinctly a Vertebrate as the highest, and no Mollusk or Articulate exhibits any transition towards a vertebrate structure.

There are, however, *hemitypic* Fishes; but their place is towards the *top* of the class instead of at its bottom. Ganoids constitute one group of this kind, between Fishes and Reptiles, as long since pointed out by Agassiz. Again, Selachians (or Sharks and Rays) constitute another, between Fishes and the higher classes of Vertebrates. This last idea also has, we believe, been suggested by Agassiz (although we cannot refer to the place where published), this author regarding the species as intermediate in character between Fishes and the allantoidian Vertebrates. Moreover, Müller long ago observed the relation of the Sharks to the Mammals in having a vitelline placenta, by which the embryo draws nutriment from the parent, as does the mammalian fetus by means of its allantoidian placenta.

Ganoids and Selachians are, thus, two *hemitypic* groups in the class of Fishes.

The scheme of grand divisions is then as follows:[2]

I.

A. Typical Mammals,
B. Hemitypic Mammals.
or Oötocoids.

II.

A. Typical Birds,
B. Hemitypic Birds.
or Erpetoids.

III.

A. Typical or true Reptiles.
B. Hemitypic Reptiles,
or Amphibians.

IV.

A. Hemitypic Fishes, or Selachians.
B. Hemitypic Fishes, or Ganoids.
C. Typical Fishes, or Teliosts.

One of the groups of hemitypic Fishes looks directly towards Reptiles, and the other towards the three higher classes of Vertebrates collectively, but especially Mammals and Birds.

[2] It is here seen that the term *Oötocoid*, applied to Marsupials and Monotremes, has great significance; and so likewise, *Erpetoids*, and *Amphibians*. *Oötocoid* is simply the Greek form of the term *semi-oviparous*.

It is plain from the preceding that the subkingdom of Vertebrates, instead of tailing off into the Invertebrates, has well-pronounced limits below, and is complete within itself.

2. *Distinctive features of the Reptilian division of Birds.*—The skeleton of the fossil Bird, discovered at Solenhofen, has some decided Reptilian peculiarities, as pointed out by Wagner, Owen, and others. But even if perfect, it could not indicate all the Reptilian features present in the *living* animal. It is, therefore, a question of interest, whether the relations of the hemitypic to the typical species in the two classes, Mammals and Reptiles—one superior to that of Birds, and the other inferior—afford any basis for conclusions with regard to characteristics of the hemitypic Birds undiscoverable by direct observation. The following considerations, suggested by analogies from the classes just mentioned, may be regarded as leading to unsatisfactory results; and yet they deserve attention.

A. *Mammals.*—(1.) It is a fact to be observed that the hemitypic Mammals are as truly and thoroughly *Mammalian*, as regards the fundamental characteristic of the type—the suckling of their young—as the typical species.

(2.) The departure from the typical Mammals is small in the *adult* individuals, especially the adult males. But it is profoundly marked in their *young*, they thus approximating in period of birth and some other respects to oviparous Vertebrates.

B. *Reptiles.*—(1.) The *adult* Amphibians, or hemitypic Reptiles, depart but little from the typical Reptiles, either in structure or habits.

But (2.) the *young*, in their successive stages, from the egg upward, partake strikingly of characters of the inferior class of Fishes.

The law seems, then, to be that the species of the hemitypic group have their principal or most fundamental resemblance to those of the class or classes below in the *young* state. We should hence conclude that the *young* of the Reptilian Birds or Erpetoids possessed more decided Reptilian peculiarities than the adults.—What these unknown peculiarities, if real, were we can infer only doubtingly from the analogies of the known cases already considered.

The characteristic of the intermediate type, on which the intermediate character depends, is, in the case of both Mammals and Reptiles, that particular one which is the special distinction of the inferior type. The types inferior to Mammals are *oviparous*, and hence the hemitypic Mammals are semi-oviparous. The type inferior to Reptiles, or that of Fishes, is distinctively *aquatic* and breathes consequently by means of *gills* instead of lungs, and hence the hemitypic Reptiles have gills in the young state.

What then are the characteristics of Reptiles that may have been presented by the inferior or hemitypic Birds? The more prominent distinctions of Reptiles are the following:

(1.) A covering of scales, or else a naked skin, instead of a covering of feathers.

(2.) A terrestrial creeping mode of life instead of an aerial or flying mode.

(3.) Incomplete circulation, and hence, to some degree, cold-blooded, instead of complete, and warm-blooded.

Now, as to the young of the Reptilian Birds, it may be inferred that—

(1.) They were unquestionably unfledged. For this is universal among birds, for a while after leaving the egg. It is quite probable that they were more completely unfledged, or for a longer time, than is common for the young of ordinary birds; for even the adult bird, judging from the Solenhofen specimen, was less completely feathered than usual.

(2.) They were unquestionably *walking* chicks. For Birds in the lower division of the class (*Præcoces* of Bonaparte) have the use of their legs immediately after leaving the egg, and seek their own food. A brood of Reptilian bird-chicks, with long tails and nearly naked bodies, creeping over the ground, would have looked exceedingly like young Reptiles—very much, indeed, as if the eggs of a Reptile had been hatched by mistake. Moreover, these Reptilian Birds were probably not only walking birds when young, but as much so as hens and turkeys are, if not more exclusively so, even when adults; for, in the inferior division of ordinary birds, the species are far inferior as flying animals to those of the superior division, and in some, as is well known, the wings only aid in running.

(3.) But the characteristics which have been mentioned under (1) and (2) are not of fundamental value, like that of the existence of gills in the young of hemitypic Reptiles, or that of the semi-oviparous method of reproduction in Oötocoid Mammals; and it would seem that there must have been some more profound Reptilian characteristic. It is therefore probable that the third distinction of Reptiles stated belonged also to the young Reptilian Bird; that is, it had incomplete circulation, and, hence, an approximation to the cold-blooded condition of Reptiles. The heart may have had its *four* cavities complete, as in Birds, and in Crocodiles among Reptiles; but, in addition, there may have been a passage permitting a partial admixture of the venous and arterial blood, such as exists not only in Crocodiles but also in the young Bird during an early stage in its development. This peculiarity in the vascular system of the young Bird of the present day ceases with the beginning of respiration. But in the Reptilian birds it may have continued

on through the early part, at least, of the life of the chick, or until it was fledged.

This conclusion is made to appear still more reasonable by the following comparison of the three obvious methods of subdividing Vertebrates, and the connection therewith of the characteristics of the hemitypic groups. These three methods are—

1. Into *viviparous* and *oviparous;* which places the dividing line between Mammals, and the inferior Vertebrates.

2. Into *warm-blooded* and *cold-blooded*, or those having perfect, and those having imperfect, circulation; which places the line between Mammals and Birds, on one side, and Reptiles and Fishes, on the other.

3. Into *pulmonate* and *branchial*, or those with lungs, and those with gills; which places the line between Mammals, Birds and Reptiles, on one side, and Fishes, on the other.

Now the characteristic of the *first* of these methods of subdivision is that on which the hemitypic group of the first class, or that of Mammals, is based. The characteristic of the *third* is that on which the hemitypic group of the third class, or the Reptilian, is based. Hence, the characteristic of the *second* should be, if the analogy holds, that on which the hemitypic group of the second class, or that of Birds, rests for its most fundamental distinction.

3. *Geological history.*—It has been observed, on page 318, that the Vertebrate subkingdom has well-drawn limits below, instead of tapering downward into Mollusks or Articulates. This feature of the subkingdom is further evident from the fact in geological history that the earliest species of Fishes were not of the *lower* group, that of Teliosts, but of the two higher, or those of Ganoids and Selachians. The Vertebrate type did not originate therefore in the subkingdom of Mollusks, or of Articulates; neither did it start from what might be considered as its base, that is, the lower limit of the class of Fishes; but in intermediate types, occupying a point between typical Fishes and the classes above.

Moreover, the inferior group did not come into existence until the Cretaceous period, in the latter part of geological history, when the Reptilian age was commencing its decline.

In the Devonian age, or closing Silurian, appeared the first Ganoids and Selachians. In the Carboniferous, Reptiles were introduced,—first the inferior Amphibians, and then typical species. Afterward, in the early part of the Reptilian age, as Reptilian life was in course of expansion, there were the first of the Reptilian Birds and the first of the Marsupials or hemitypic Mammals (with probably some typical species of each of these classes). Thus the Vertebrate type, commencing at the point

of approximation of Reptiles and Fishes, expanded until each of its higher classes had representative species, before the inferior division of true or typical fishes—Teliosts—came into existence. Afterwards, in the Cenozoic, the true or typical Birds and Mammals had their full expansion.

The Vertebrate type, therefore, not only was not evolved along lines leading up from the lower subkingdoms, but was not, as regards its own species, brought out in lineal order from the lowest upward. The subkingdom has, therefore, most evidently a separateness and a roundness below, so to speak, or an entireness in its inferior limits, which belongs only to an independent system.

We find in the facts no support for the Darwinian hypothesis with regard to the origin of the system of life.

ART. XXIX.—*The Classification of Animals based on the principle of Cephalization;* by JAMES D. DANA.—Number I.

As the principle of cephalization is involved in the very foundation of the diverse forms that make up the animal kingdom, we may look to it for authoritative guidance with reference to the system that prevails among those forms. Some of its bearings on zoological classification have already been pointed out.[1] I propose to take up the subject more comprehensively; and, in the present article, to bring the light of the principle to bear on the relations of the subkingdoms, classes, orders, and some of the tribes of animal life.

It is essential, first, that the methods or laws of cephalization be systematically set forth, that they may be conveniently studied and compared. The following statement of them is an extension of what has already been presented.

As an animal is a *cephalized* organism, (or one terminating anteriorly in a head,) the anterior and posterior extremities have opposite relations. The subdivision of the structure into *anterior* and *posterior* portions has therefore a special importance in this connection. As these terms are used beyond, the *anterior* portion properly includes the head, which is the seat of the senses and mouth, with whatever organs are tributary to its purposes, anterior in position to the normal locomotive organs; the *posterior* portion is the rest of the structure. The anterior is eminently the cephalic portion. The digestive viscera from the stomach backward, and the reproductive viscera, belong as characteristically to the posterior portion.

[1] Expl. Exp. Report on Crustacea, p. 1412, 1855; this Journal, [2], xxii, 14, 1856; xxxv, 67, xxxvi, 1, 1863.

It follows, further, from the cephalized nature of an animal, that its *primary centre of force*, or the point from which concentration and the reverse are to be measured, anteriorly and posteriorly, is in the head, near the anterior extremity of the structure. In an Insect or Crustacean, its position is between the mouth and the organs of the senses—over which part the cephalic mass is located. This is sustained by embryogeny; and also by the fact, that, as the two most fundamental characteristics of an animal are its being sense-bearing and mouth-feeding, the mouth, on descending to the simplest of animals, is the last part to become obsolescent. Only in the inferior Invertebrates is the position of the mouth approximately *central* in the structure, as explained on page 328.[3]

1. *Methods of Cephalization.*

The methods, according to which the grades of cephalization are exhibited, may be arranged under the following heads:

A. *Size* (*force-measured*) *of life-system:* each type, between Man at one extreme and Protozoans at the other, having its special range of variation in this respect.

B. *Functional:* or variations as to the distribution of the functions *anteriorly* and *posteriorly*, and as to their condition.

C. *Incremental:* or variations as to vegetative increment, that is, as to amplitude, and multiplicative development.

D. *Structural:* or variations in the conditions of the structure, —whether (1) compacted, or, on the other hand, resolved into normal elements; (2) simple, or complex by specialization; (3) defective, or perfect; (4) animal-like, or plant-like.

E. *Postural:* or variations as to posture. (Only in Vertebrates.)

F. *Embryological:* or variations connected with the development of the young.

G. *Geographical distribution.*

For greater convenience and uniformity, the methods under these heads are mentioned beyond as they appear when viewed along the *descending* line of grade, instead of the ascending. This is, in fact, the more natural way, since the typical form in a group—the fixed point for reference—holds a position towards the top of the group. The methods, as given, are therefore more strictly methods of *decephalization* than of cephalization; but the former are simply the reverse of the latter.

A. SIZE (OR FORCE) OF LIFE-SYSTEM.

1. *Potential.*—Exhibited in less and less force and size of life-system with decline of grade (and the reverse, with rise of

[3] There may also be one or more *secondary* centres of force; but they are, as regards the subject before us, of compartively small importance. The independent development of the abdomen and cephalothorax in Crustaceans is a case of the kind, as explained elsewhere by the writer. See paper on the Classification of Crustaceans referred to.

grade); as that in passing from the type of Megasthenes (Quadrumanes, Carnivores, Herbivores and Mutilates) to that of Microsthenes (Chiropters, Insectivores, Rodents, and Edentates); or from that of Decapods to that of Tetradecapods among Crustaceans—in which latter case, unlike the former, there is also *retroferent* decephalization; and so, generally, in passing from a higher to a lower type, it being equivalent to passing to a type of smaller and weaker life-system. See further, this volume, pp. 8 and 338.

B. FUNCTIONAL.

2. *Retroferent.*—A transfer of functions backward that belong anteriorly in the higher cognate type.

Under this method, there are the following cases:

a. A transfer of members from the cephalic to the locomotive series; as the transfer of the fore-limbs to the locomotive series in passing from Man to brute Mammals; that of a pair of maxillipeds or posterior mouth-organs to the locomotive series in passing from Insects to Spiders; that of two pairs of maxillipeds to the locomotive series in passing from Decapod to Tetradecapod Crustaceans.

b. A transfer of locomotive or prehensile power and function, more or less completely, from the anterior locomotive organs to the posterior.

c. A transfer of the locomotive function, more or less completely, from the limbs (these often becoming obsolete) to the body, and mainly to the caudal extremity.

Under *b* and *c*, the condition may be described as—

(*a*) *Prosthenic*, (from the Greek *προ*, *before*, and *σθενος*, *strong*,) if the anterior locomotive organs have their normal superiority.

(*b*) *Metasthenic* (from *μετα* *after*, etc.), if a posterior pair is the more important and the anterior are weak or obsolete.

(*c*) *Urosthenic* (from *ουρα* *tail*, etc.), if the posterior part of the body, or the caudal extremity, is the main organ of locomotion.

Ordinary flying Birds are *prosthenic*, while the *Præcoces* (Gallinaceous Birds, Ostriches, &c.), being poor at flying, or incapable of it, are *metasthenic*, and they thus exhibit their inferiority of grade. Hymenopters, Dipters, Lepidopters, &c., among Insects, are *prosthenic*, while Coleopters, Orthopters, Strepsipters, etc., in which the fore-wings (the *elytra*) do not aid in flight, or but little, are *metasthenic*. Fleas, which are degradational species, related to Dipters, have the third or *posterior* pair of legs much the longest and strongest. Among Macrural Crustaceans, the strongest legs are, in the higher species, the *first* pair; in others inferior, the *second;* in others still inferior (the Penæids) the *third* pair.

(See further, for examples, this Journal, [2], xxii, 14, and xxxvi, 1.)

Viewed on the ascending grade, this method is the *preferent.*

3. *Pervertive.*—A subjection of an organ to any abnormal function inferior to that normal to it;—as in the adaptation of the nose of the Elephant to prehension; of the antennæ of many inferior Crustaceans to prehension or locomotion; of the maxillipeds of inferior Macrurans to locomotion; of the forehead in many Herbivores to purposes of defense.

The perverted nose of the Proboscideans is one of the indications of their inferiority to the Carnivores; but it is not necessarily a mark of inferiority among Herbivores themselves, as the faculty of prehension is one of those especially characterizing Carnivores and other higher Mammals, and nearly all Herbivores fail of it.

Viewed on the ascending grade, this method and the following may be included under the term, *perfunctionative.*

4. *Defunctionative.*—Exhibited in the defectiveness or absence of the normal function of an organ;—as in the absence of the function of prehension from the fore-limbs of Herbivores (this prehension in the fore-limbs belonging to the Mammalian type); and that of locomotion mostly from all the limbs in the Mutilates; that of locomotion from the female Bopyrus; that of locomotion from Cirripeds and other attached animals; that of the sense connected with the *second* pair of antennæ (and probably also the *first*, these organs being obsolete) in the Lernæas and Cirripeds, these antennæ being simply prehensile organs in a Lernæa, and constituting the base of the peduncle in an Anatifa.[3]

This degradation and loss of functions is connected often with the *elliptic* and *amplificative* methods of decephalization (see beyond). It is connected with the latter in the Bopyrus, and also in Cirripeds and other attached species.

C. Incremental.

5. *Amplificative.*—Exhibited in an elongation or general enlargement of the segments or members, and an increased laxness of the parts. Includes the cases—

a. Lengthening, widening, or laxness in the *anterior* portion of the body; the same in the *posterior* portion.

b. An abnormal enlargement of the general structure.

The elongation or enlargement which takes place with decline of grade is mainly *posterior*, it being small anteriorly, and sometimes none at all. In passing from the Brachyural to the Macrural type of Crustaceans, the change anteriorly is princi-

[3] See *Expl. Exp. Report on Crustacea*, p. 1393, and plate 96, where it is shown that the antennæ of the young Anatifa have a sucker-like organ for attachment, and become, in the metamorphosis, the bottom of the peduncle by which the adult Anatifa is attached.

pally in an increased laxness and lengthening of the parts, with little increase in the dimensions of the body anterior to the mouth; while the abdomen (or *posterior* extremity) is enlarged 10 to 50 times beyond the bulk it has in the Crab. Descending from a snail to an oyster, there is diminution anteriorly and great enlargement posteriorly, and the animal is little more than a visceral sac.

In less marked cases of the *amplificative* method, there is only an attenuation or lengthening of the body and limbs, as in many Neuropters, Orthopters, Homopters, wading Birds, etc. The Lepidopters, also, in their very great expanse of wing, exemplify this method. In species that are attached, as the Cirripeds, the young are usually free; and it is only when they begin to outgrow, amplificately, the minute life-system (Entomostracan in the Cirripeds) that they become fixed. As attached animals, they often attain great size.

Viewed on the ascending grade, this method is the *concentrative;* and it is exhibited in the increased abbreviation and condensation of the anterior and posterior members and segments, or of the whole structure.—For examples, see further volume xxii and the present, as already referred to.

6. *Multiplicative.*—Exhibited in an abnormal multiplication of segments or members; as in Myriapods, Worms, Phyllopods, Trilobites, etc. There may be—

a. Simple multiplicative; as in the superior Myriapods, the Chilopods, in which the body-segments, thus multiplied, have each its single or normal pair of members.

b. Compound multiplicative; as in the Myriapods of the Iulus division, or Diplopods (Chilognaths), in which there is a duplication of the pair of legs of a body segment. The name *Diplopod*, adopted by Gervais and some other authors, has the advantage of having thus a dynamical value.

The multiplicative method is, in general, a degradational one. When it affects only subordinate parts of the structure, as the length of the tail of Mammals, or of Reptiles, etc., the forms are not necessarily degradational. But when it affects the general structure, and the types are indefinite in segments, like the Myriapods, Worms, and Snakes (see page 4 of this volume), the forms are degradational. In Mammals, the tail may be said to have indefiniteness of limit; but, since this part is only an appendage to the body and has little functional importance, its elongation cannot properly be regarded as a mark of degradation, although one of inferiority. When, however, the posterior extremity is, in magnitude and importance, a part of the main body structure itself, as in Snakes and Fishes, the case is properly an example of multiplicative degradation.

The abnormal number of segments under the multiplicative

method may arise from a self-subdivision of enlarging normal segments, or from additions beyond the range of the normal number. The many joints of the antennæ in Crustaceans of the Cyclops group, the writer has shown to result through the former method, and the multiple segments of Phyllopods may be of the same origin: but there are no facts yet ascertained that would refer the multiplication of segments in Myriapods and Worms to this method.

Viewed on the ascending grade, this method is the *limitative*.

D. Structural.

7. *Analytic.*—Exhibited in a resolving of the body-structure, or of an organ, more or less completely, into its equal normal elements, or in a tendency to such a resolution.

A relaxed state of the cephalic power leads to a relaxed and elementally-constituted structure. When this method characterizes strongly the general structure, the form is usually degradational; as in Myriapods, Worms, larves of Insects,—these structures consisting of a series of nearly similar rings, (the normal elements of an Articulate,) without a subdivision into head, thorax and abdomen. Fishes, of the Vertebrate type, are, as nearly as may be, in this elementalized condition. An approximation towards analysis or resolution of the body appears in the absence of the constriction between the head and thorax in Spiders and Crustaceans; and still further, in the absence of the constriction between the thorax and abdomen in the lowest of Spiders, the Acaroids.

Under this method, there is, in no case, among adults or larves, a complete analysis or resolution of the head into normal segments; the closest approximation to it, in Insecteans and Crustaceans, occurs in the Gastrurans (Squilla group) as explained in a note to page 6 of this volume. But here the mandibular and one, two, or more maxillary segments are still united. In an Insect, the head, as stated on page 234 of this volume, contains six normal segments, and the thorax three; and yet the thorax has 3 to 5 times the bulk of the head;—showing a condensation in the head-part equal to 6 to 10 times that of the thorax. Concentration in an animal structure is therefore eminently cephalic concentration, or, in a word, *cephalization*,—the head being the part most condensed, and least liable to occur resolved into its elements.

The analytic method, viewed on the ascending grade, is the *synthetic*.

8. *Simplificative.*—Exhibited in increased simplicity of structure, and in an equality of parts that are normally identical. The cases are—

a. Simplicity from diminished number of internal or external organs for carrying on the processes of life; as in the absence of

distinct respiratory organs, or of different parts in the digestive system, etc.; or the union of the sexes in one individual, etc.; —a simplification which reaches its extreme limit among Radiates in the Hydra, and among animals, in the Protozoans.

b. Simplicity from equality in parts normally alike; as, equality in the height of the teeth of some of the earliest of Tertiary Mammals; in the annuli of Worms. This case is related to the analytic.

Viewed on the ascending grade, this method is the *differentiative*, the facts exhibiting which are embraced under the well known law of differentiation or specialization, which is fundamental in all development.

Differentiation internally, as it multiplies and perfects the means of elaborating the structure, is attended with an increasingly higher grade of chemical change, more perfect nutrition, and more complete decarbonization of the blood; and implies, therefore, improvement in all tissues, a more sensitive nervous system, and greater cephalic power and activity. And from the reverse comes the reverse effect.

9. *Elliptic.*—Exhibited in the defectiveness, or absence, of segments or members normally pertaining to the type of the *order* or *class* containing the species. The cases are—

a. Incomplete, or deficient, segments or members, in either the *anterior*, or the *posterior* portion of the body; as with certain teeth in the Herbivores, toes in the foot of the horse, one or two pairs of antennæ in some inferior Crustaceans.

b. Defective, or deficient, senses.

When the deficient parts are only those that are normally deficient in the type of the *order* or *class*, the examples may come under the *simplificative* above. It differs from the *defunctionative* in implying a deficiency not of function only, but of organ or member. The foot of the horse is elliptic, whether viewed with reference to the Animal-type, or the Megasthenic-type. The Fish is elliptic as regards limbs, if considered with reference to the Vertebrate-type, but not so with reference to the Fish-type, unless the fins corresponding to the Vertebrate limbs are wanting.

Viewed on the ascending grade, this method is the *completive.*

10. *Phytozoic.*—Exhibited in a departure from the Animal-type through a participation in structural features of the Plant-type, that is, through a plant-like arrangement of the organs.—The cases are—

a. A radiate arrangement of external organs; as in the Bryozoans and inferior Tunicates.

b. A radiate arrangement of internal as well as external organs; as in Radiates.

c. Perfect, or nearly perfect, symmetry in the radiation, instead

of eccentric or irregular forms. Perfect symmetry is most general where the number of rays is based on the numbers 4 or 6 (which, it is to be noted, are multiples of 2 and 3), 4 being the number for the class of Medusæ, and both 4 and 6 occurring in that of Polyps. But if the number of rays is 5, as in the highest of Radiates, the Echinoderms, while examples of perfect symmetry occur, there are many cases of unsymmetrical forms (as in the Spatangi) in which the Radiate type seems to tend to emerge from phytoid towards true animal-like forms. In the regularly radiate, the mouth is central or very nearly so, while in the Spatangi, there is something of the fore-and-aft form of the animal.

Among species under the true animal-type, there are forms showing an approximation to the central position which the mouth has in Radiates. In a Limulus, for example, the mouth-aperture is only one-half less remote from the anterior margin of the body than from the posterior (base of caudal spine). The Limuli are extreme in *amplificative* decephalization and in lowness of grade. Under the *multiplicative* method also, there is something similar in Worms and Myriapods. The head is here strictly at the anterior extremity; but the cephalic force has so feeble control, that joints multiply behind; and in the lowest of Worms, each separate segment is nearly equal in all functions to the cephalic segment. Moreover, in the embryological development of an Annelid, the first segment (with its pair of appendages) that is formed after the appearance of the head is not the anterior one close to the head, but the *eighth* (or one near this); and from this point the rings form in succession posteriorly, and also towards it from the head; as if, in these *multiplicate* species, there was a *secondary centre of force* distant from the front which preponderates over the *primary* one.

This method viewed on the ascending grade is the *holozoic*, (from ὅλος all, and ζωον animal); it is exhibited in a rise from the plant-like type to the true animal-like type.

E. Postural.

11. *Postural.*—Exhibited in an increasing proneness in the position of the nervous system—the extremes being *verticality* in Man, and *horizontality* in the Fish.

F. Embryological.

12. *Prematurative.*—Exhibited in precocity of young or larves.

Thus, the chicken, as soon as born, runs about and seeks its own food, while the young of those Birds which belong to the superior group,—the true flying Birds—remain helpless until able to fly; a fact recognized in Bonaparte's classification of Birds. So the young colt or calf (Herbivorous) is on its legs almost as soon as born; but the young kitten (Carnivorous, and higher in type) is for a considerable time helpless.

Prematurity has often been recognized as evidence of low development and low rank; and the following is the explanation of it.

When an animal has reached the condition required for locomotion and for the care of itself, it has already the essential faculties of an adult; and although these faculties of locomotion and self-feeding are of comparatively low grade, the animal possessing them is approximately mature in its cephalic forces, and afterwards rises but little with growth. Prematurity hence involves inferiority. The pupa-state of an Insect is a means of higher development the more perfect its inactivity. For this complete rest allows all the forces of the individual to be concentrated on the internal processes, and favors, therefore, that cephalic growth which makes a special demand on these forces; while in an *active* pupa (or rather the larve that passes through no pupa-state), activity, whether that of locomotion, or of digestion, constantly exhausts force; and only the balance, not thus run away with, goes towards the maturing process. With such an open outlet of force, the animal may mature physically, that is, grow and perfect its outer structure; but cephalically, or, in all those points of structure, as well as psychical powers, that are connected with superior cephalic development, it makes little advance.

Hence, (*a*) those insects whose larves are essentially like the adults and undergo no metamorphosis are inferior in type,—as generally so recognized.

Again, (*b*) those Insects (as most Hymenopterous) whose larves are footless grubs are superior in type to those (as the Lepidopterous) whose larves are most highly developed and active.

Viewed on the ascending grade, this method is the *permaturative.*

13. *Gemmative.*—Exhibited in multiplication by buds. Budding may produce—

a. Perfect individuals, capable of egg-production.

b. Individuals capable only of budding, and giving origin to a perfect egg-producing individual as the last of a series of buddings.

c. Caducous, or persistent buds; the *latter* leading to compound forms, either branching, lamellar, or massive.

This power of reproduction by buds occurs in many Worms, both superior and inferior; in Bryozoan and many Ascidian Mollusks; in Polyps and many other Radiates. The production of persistent buds is the lowest grade, and is common in the budding Mollusks and Radiates, but not the Articulates. Among budding Articulates, case *b* appears to be of lower grade than case *a.*

This method is allied to the *multiplicative*, p. 325. It is also *phytozoic* (p. 327), or a plant-like feature in animal life.

14. *Genetic.—Number of young or eggs.*—As is well known, there is a mark of grade in the number of eggs or young produced at a single period or in a given time—the number, other things equal, being inversely as the rank or grade of the species.

15. *Thermotic.—Temperature required for embryonic development.*—Another mark of grade is afforded by the temperature required for egg-development:—for, in general, the higher the temperature, the higher the grade. Thus, the eggs of Birds require heat above ordinary summer heat, while those of Reptiles do not. The embryos of Mammals require still higher and more uniformly continued heat until their maturity, the Oötocoids alone excepted, in which birth is premature. The eggs of some Hymenopterous Insects mature inside of the larves of other Insects, where they are never exposed to a temperature of 32° F.; while those of ordinary Lepidopters and many other species mature in the summer heat, and may stand a temperature below 0° F.

The necessity of a higher temperature indicates, ordinarily, that the chemical processes in the vital economy are of a higher or more delicate character, or those required for a higher grade of cephalization.

G. Geographical Distribution.

16. *Habitational.*—(1.) *Terrestrial species higher than aquatic.*—This law, announced by Agassiz, is also directly dependent on the conditions determining the grade of cephalization.

a. In the case of *aquatic* species, the ova, as well as the adult animals, are bathed in a liquid that penetrates to the interior, and dilutes, to some degree, the nutrient or developing fluids; and, under such circumstances, the grade of chemical or vital evolution cannot be as high as in the atmosphere. The germ must therefore be one of an inferior kind. Aquatic animals are, in an important sense, *diluted* animals.

b. Again, *terrestrial* species whose ova are hatched in water, or whose young are aquatic, are for the same reason inferior, as a general rule, to those whose ova are hatched on the land.

Aquatic development or life is one of the most important marks of low grade. Among embryological characteristics, it has often a profounder value than prematurity. The *inferior division* of a *class*, *order*, *tribe*, and even *subordinate group*, is often one consisting either of *aquatic* species, or those that are *semiaquatic* (aquatic in habit though not strictly so in mode of life, or aquatic in the young state when not in the adult).

(2.) *Living* (a) *in impure waters, or those abnormal in condition; or* (b) *in deficient light, as in shaded places, or the ocean's depths, a mark of inferiority.*—Muddy waters, or salt waters excessively saline as in some inland lakes, or waters only brackish, are here included.

But *oceanic waters*, although saline, are not properly impure. Of the subkingdoms and the classes containing aquatic animals, the *highest* groups are those of *marine* waters. Thus, the highest of Mollusks, the Cephalopods, are marine; the highest of Radiates, the Echinoderms; the highest of Fishes, the Selachians; of Crustaceans, or the Maioid or Triangular Crabs; of Worms, the Dorsibranchs; of Acalephs, all but the Hydroids are marine; while *all* species of Echinoderms and Polyps are marine. Among the subordinate groups there are some fitted particularly for fresh water. Types that belong to fresh water sometimes have inferior species in brackish or salt water; and those that belong to salt water sometimes have inferior species in brackish or fresh water.

(3.) *Species of cold climates inferior to those of warm.*—According to the 15th canon, the highest oviparous animals should be tropical species; but not necessarily so the viviparous Mammals, since, with them, the requisite temperature for embryonic development is obtained within the parent.

An exception to this, as regards oviparous species, is afforded by Crustaceans; for, as shown by the writer, the highest kinds, the Maioid or Triangular Crabs, have their fullest development in the cooler temperate zone.

(4.) *Having a wide range with regard to any of the earth's physical conditions, as* (a) *climate,* (b) *height,* (c) *oceanic temperature,* (d) *oceanic depth,* (e) *hygrometric conditions, etc., commonly a mark of inferiority.*—For, if the development of a high order of cephalized life requires rest for a while in the young, as, for example, the nursing time in the higher Mammals and Birds and the Pupa-state in Insects, and also an absence from diluting or impure waters and the presence of the full light of the sun, it should also equally demand precise or narrowly restricted limits in all physical conditions, these being essential to the more refined or delicate chemical or vital processes. Man is the chief exception to this law,—and for the reason that he is not simply in and of nature, but also above nature, and has the will and power to bring her forces under subjection, overcoming the rigors of climate and subjugating other inimical agencies by his art. Protophytes and Man are the only species that have the range of the world—the one because so low, the other, so high. The Dog accompanies Man in his wide wanderings: but only through the virtue which is in Man, who provides the artificial heat, protection and food his brute attendant needs. Even the human race dwindles in extremes of climate, either hot or cold.

Recapitulation.—The following are the names of the several methods of cephalization pointed out, both those based on the descending and ascending lines of grade.

	Descending.	*Ascending.*
A. Size of Life-system, -	1. Potential.	1. Potential.
B. Functional, - - - -	2. Retroferent.	2. Preferent.
" - - - -	3. Pervertive.	3. } Perfunctionative.
" - - - -	4. Defunctionative.	4. }
C. Incremental, - - -	5. Amplificative.	5. Concentrative.
" - - - -	6. Multiplicative.	6. Limitative.
D. Structural, - - - -	7. Analytic.	7. Synthetic.
" - - - -	8. Simplificative.	8. Differentiative.
" - - - -	9. Elliptic.	9. Completive.
" - - - -	10. Phytozoic.	10. Holozoic.
E. Postural, - - - - -	11. Postural.	11. Postural.
F. Embryological, - - -	12. Prematurative.	12. Permaturative.

The remaining terms fall into both columns.

With *ascending* grade, the changes are mostly *concentrative;* with *descending*, they are *diffusive* or *decentrative.*

2. *Additional Observations.*

1. *Typical, Degradational and Hemitypic forms.*—Typical species are those within type-limits, and *degradational* those outside of the same.[4] But, as groups of all grades have each their own type and type-limits, species may be typical in one relation, and degradational in another; as Fishes, for example, while degradational Vertebrates, have still their own type and type-limits, the Teliosts being the typical Fishes, or those within these limits.

The characteristics of a type, in any case, are those fundamentally distinctive of the group. As to that of the animal kingdom at large,—we observe that an animal is (1) a fore-and-aft, (2) cephalized, (3) forward-moving organism. The type-idea is hence expressed in a structure having (1) fore-and-aft and dorso-ventral polarity; (2) a head at the forward extremity containing the seats or organs of the senses, as well as the mouth and mouth organs; and (3) the power of locomotion, if not also limbs for the purpose. Consequently Radiates, as they fail in the first criterion, are not within type-limits; neither are any *attached* species of animal, and only in a partial degree species without limbs for locomotion.

Again, the Vertebrate-type, in addition to having the characteristics of the animal type and the vertebrate structure, is essentially terrestrial, and, therefore, the requisite limbs and structure for terrestrial life are in the type-idea. Fishes are therefore outside of type-limits, or are degradational species.

The Mammal-type, the highest under Vertebrates, in addition to the characteristics of the Vertebrate type, has that of being viviparous in its births, embracing under this quality, that of sustaining the embryo by placental nutrition until its maturity

[4] The term *degradational* has no reference to any method of origin by degradation: it implies only that the forms so called represent or correspond to a degraded condition of the type.

(as is not true of the oviparous); and with this there is also that of sustaining the young for a while after birth, by suckling. Hence, the Oötocoids, in which there is only imperfect placental nutrition and birth is premature, and there is an approximation thus to oviparous species, constitute a degradational type.

The Megasthene-type, under Mammals, has its degradational group in the Cetaceans or Mutilates, which fail mostly of limbs and are aquatic species; and the Carnivore its degradational group in the Seal and related Pinnipeds. The latter have the type-structure of the Carnivores; while the Mutilates have the type-structure of neither Carnivores nor Herbivores, and are therefore an independent type under the division of Megasthenes.

Again, the Bird-type, in addition to the characteristics of the Vertebrate-type, embraces features adapting the animal to flying, as feathers and wings; perfect circulation; and also a vertebral column which is posteriorly limitate, instead of one admitting of a caudal elongation,—somewhat as Insects and Spiders are *closed* types behind, in contrast with the *multiplicate* Myriapods. Hence the Reptilian Birds, having *indefinite* posterior elongation, and some other Reptilian characteristics, are outside of type-limits. So, again, under the subdivisions of Birds, species that have the wings unfledged or but half-fledged, and which, therefore, cannot lead an *aerial* life, are degradational; and species that have the feet imperfectly digitate by their being web-footed, and which therefore lead a *semiaquatic* life, are semi-degradational in the group to which they may belong.

These examples are sufficient to illustrate the uses of the words typical and degradational.

It is of the highest importance, for the correct classification of species, that in all cases it should be rightly determined whether a degradational genus is degradational to the *family* to which it belongs, or to the *tribe*, or *order*, or to a still higher division. Although Seals and Whales are similarly adapted to the water, it is plain, to one familiar with the species, that the former are degradational Carnivores, and the latter degradational Megasthenes, as stated above. But like cases come up in every part of the animal kingdom, and close study is necessary for a true decision. The first preliminary towards such a decision is a clear idea of the class-type, order-type, tribe-type or subordinate type under which the genus or group falls.

The term *hemitypic* has been shown in the preceding paper to imply, in general, a grade of the degradational. But, in some groups, as in the class of Fishes among Vertebrates, it is applicable to cases which are not typical because of their being intermediate between the type of the group and a *superior* type or types (p. 317).

Typical groups, or, more properly, the groups above the degradational, may be of several grades. Thus, under Vertebrates, the classes of Mammals, Birds and Reptiles, represent different grades of Vertebrate types, and the grades may be designated, in order, *Alphatypic*, *Betatypic*, *Gammatypic* (from the first three Greek letters α, β, γ). Under Mammals, also, there are three grades, those of Man, Megasthenes, and Microsthenes; then, below these, the hemitypic or degradational Oötocoids. Under tribes, families and genera, the number of grades may be large.

Degradational subdivisions are strictly *hypotypic*, or *below* the typical range.

Typical subdivisions, or those above the degradational, are not, in all cases, *true* typical, as well exemplified by the orders of Fishes; the Teliosts alone being true typical, and the Ganoids and Selachians, called *hemitypic* above, being properly *hypertypic*, or *above* the typical range. Another example of this is afforded by the subdivisions of Megasthenes. Carnivores and Herbivores are different grades of the *true typical*, the former the more perfect, or *eutypic;* while the Quadrumanes or Monkeys are *hypertypic*, being an *intermediate* type between the typical Megasthenes and Man; and the Mutilates (Cetaceans, etc.) are *hypotypic*. Among the Microsthenes, the Chiropters or Bats are *hypertypic*, the Insectivores and Rodents *true typical* of two grades, and the Edentates *hypotypic*.

Among the subdivisions of Mammals there are *three* grades of true typical; and, of them, Man is *archetypic*, as he has been styled, being the *one perfect* type.

Degradational forms may be classed under three heads, as follows:

1. *Degenerative;* in which the forms are thoroughly animal in type. The methods of decephalization which lead most commonly to degenerative forms are the analytic, multiplicative, elliptic and defunctionative.

2. *Hemiphytoid;* when, without an *internal* radiate structure, the species are (*a*) attached to a support, like plants (see *defunctionative* method, p. 324); *b*, budding (*gemmative*, p. 329); *c*, radiate externally (*phytozoic*, case *a*, p. 327).

The externally radiate structure is a lower grade of hemiphytoid degradation than either being attached, or gemmate.

3. *Phytoid* (from φυτον, *a plant*); when the structural arrangements are *internally*, as well as externally, radiate (Phytozoic, case *b*).

As Radiates have no limbs and but imperfect senses, the higher grades among them are manifested most prominently in the conditions of the nutritive system. Some of them (the Echinoderms) are superior, as animals, to the lower *hemiphytoid* species such as the Bryozoans.

2. *Further exemplifications of the preceding methods of cephalization.*—In order to give greater clearness to the explanations which have been made on the preceding pages, the application of the terms expressing the methods of cephalization to grades of species may here be further illustrated.

In the class of Crustaceans, the distinction between the 1st and 2nd orders, or Decapods and Tetradecapods, depends on case *a* under the *retroferent* method—a transfer of members from the cephalic to the locomotive series. In connection with it, there is also an exhibition, to some extent, of the *analytic* method, more of the segments of the body in the latter being free, and all, more regular or normal in form.

Under Decapods, the difference between the 1st and 2nd tribes, the Brachyural and Macrural, depends mainly on the *amplificative* method—there being in the latter, by an abrupt transition, greater length and laxness before and behind. Under the *analytic*, also, the lengthened abdomen in the Macruran has its normal number of segments and members.

Among the subdivisions of *Macrurans*, the *retroferent* method appears prominently in the transfer of force from the *first* pair of legs to the *second* and, among the lower genera, to the *third* pair (see p. 323); the *amplificative*, in the length of antennæ in some families, and in the length of abdomen as compared with that of the cephalothorax in others; the *elliptic*, in the absence of posterior cephalothoracic members, and also the obsolescence of the abdominal members in many Schizopods or degradational Macrurans; the *pervertive*, in the outer maxillipeds taking the form and functions of feet, as in many inferior Macrurans.

Under *Tetradecapods*, the difference between the 1st and 2nd tribes, or Isopods and Amphipods, depends on the very same methods as that between the 1st and 2nd under the Decapods: that is, on the *amplificative*, as shown in the greater length of cephalothorax and the elongated abdomen, and on the *analytic*, the lengthened abdomen having its normal segments and approximately normal members.

Under the Amphipods, the *amplificative* method is variously illustrated; the *elliptic* in the obsolescent abdomen of the Caprellids, as well as in the absence or obsolescence in many species of two pairs of thoracic legs.

Again, in the class of Insecteans, the distinction between the 1st and 2nd orders, or Insects and Spiders, depends on *case a* under the *retroferent* method (see this vol., p. 3); and, in connection, there is an exhibition of an incipient stage of the *analytic*, the head and thorax in Spiders constituting a single mass (p. 326).

Under Insects, the difference between the two highest divisions, *Prosthenics* and *Metasthenics*, depends on *case b* under the *retroferent* method, or a transfer of the flying function mainly or wholly

to the posterior pair of wings. And the third is a degradational group, in which, by the *amplificative*, *analytic* and *elliptic* methods, the species (Lepismæ, etc.) are wingless and larve-like.

Among Herbivores, the Elephant shows superiority (1) in having, as in Carnivores, the teeth (its tusks) for defensive weapons; (2) in having, as in Carnivores, the power of prehension, a quality, however, transferred from the teeth to one of the organs of sense, the nose; this organ of prehension also aids in defense; (3) in having the normal number of toes; (4) in having pectoral mammæ, as in the highest Megasthenes or Quadrumanes, the highest Microsthenes or Bats, and also in Man. The great size is not a mark of overgrowth and inferiority, for the animal is neither stupid nor sluggish. The Ruminants are inferior to the Elephant in having, not an *inferior* organ of sense, but the forehead, or typically the most important part of the head, perverted to use for self-defense; and also in other ways. Among Ruminants, the Stag or Elk-type shows superiority to the Ox-type, in (1) its more compact and smaller head; (2) its less magnitude *posteriorly*; (3) its limbs adapted to fleet motion; (4) its fore-limbs adapted for climbing and clinging, giving them a special *prosthenic* character and great superiority to those of the Ox. The Horse-type shows inferiority to the Elephant-type, in (1) its long head and neck (amplificate); (2) its one-hoofed foot; (3) its being *metasthenic*, the hind legs serving as the principal organs of defense; and also in the characters mentioned above.

The discussion of the subject of classification beyond, will be found to be a continued exemplification of the laws of cephalization, and we refer forward for additional elucidation.

3. *The forms, resulting from the expression of the same law of cephalization in diverse groups, often similar; and hence come some of the analogies between groups, or their osculations.*—It is apparent that the grades of cephalization may have expression in *any* division of the animal kingdom, and that hence may come *parallel* results as to form. For example, there may be cases of *amplificative* decephalization—or of long-bodied or long-legged species—in the different orders or tribes of Insects; and, when so, the species, in these different groups thus characterized, will be, in a sense, representatives of one another, and the groups will "osculate" at such points. One example is that of Orthopters and Neuropters through the Mantids in the former and the Mantispids in the latter; also, that of Dipters and Neuropters, through the slender Tipulids of the former. The same may be exemplified among the orders of Birds. The degradational feature, for example, of webbed feet, or that of defective wings may characterize the inferior species of different subdivisions, and so produce

osculant groups; so may the *amplificative* feature of great length of limb and neck, the Herons among the Altrices, thus representing the Grallatores among the Præcoces.

The osculations or close approximations of classes, orders, tribes, etc., are thus often connected with like expressions of the methods of cephalization.

4. *Forms resulting from high and low cephalization sometimes similar.*—High and low cephalization often lead to similar forms, the former through cephalic *concentration*, the latter through cephalic and general feebleness; just as a thing may be small, when the material is condensed or concentrated, and equally small when dilute and there is little of it. Thus the Crab has a very small memberless abdomen, from a contracting of the sphere of growth through concentrative cephalization; on the other hand, the Schizopod has a memberless abdomen, through a limitation of the sphere of growth resulting from mere feebleness in the life-system. The abbreviated memberless abdomen of the Caprellid and the obsolescent spine-like abdomen of the Limulus are other examples among Crustaceans of this *elliptic* decephalization. See also page 6 of this volume for a comparison of a Limulus and an Insect. The Butterflies have very large wings through the amplificative method; but some inferior nocturnal species have the wings narrow through inferiority of grade, on the above principle, and not properly through concentration and elevation.

There is, in general, no danger of confounding the two cases, because the accompaniments in the structure of the superior species, as well as those of the inferior, commonly indicate their true relations, at once, to the mind that is well versed in the department of zoology to which the species belong. But there are many cases in which it is not safe to make a hasty decision.

5. *Uniformity of shape and size in any group greater among the higher typical species than among the lower typical or degradational species.*—On the higher typical level in any class, order, tribe, &c., the type is represented generally in its greatest number of species, and always under the least extravagance of form and size. Thus, Insects, the higher typical division of Insecteans, are vastly more numerous in species, and less diversified in size, form and structure, than Crustaceans or Worms. And, under Insects, the Hymenopters have little variety of form of body, and form or size of wings, compared with the Neuropters, Lepidopters, Homopters and even the Coleopters; and the Coleopters, little compared with the Orthopters. The fantastic shapes, in all cases, occur in the inferior typical or the degradational groups. In these, cephalization is of low grade, and as a consequence of this relaxing of the system, or its inferior concentration, the forms run off into varied extravagances.

6. *Classification hereby placed on a dynamical or sthenic basis.*—The laws of cephalization, as is apparent from the explanations which have been made, are based upon the idea that an animal is centralized force; and that the degree of concentration of this force may be exhibited in the structure; that, consequently, the various grades of species or groups become apparent, to some extent, through size and form, and their determination is thus, in part, a matter of simple measurement. Dimensions or spatial conditions have a relation to force in the animal kingdom as well as in that of the celestial spheres.

Rank or grade are thus brought to the rule and plummet, and classification, thereby, has a dynamical basis. The distinctions between groups have a dynamical or sthenic character, and all subdivisions in classification, when thoroughly understood, will have recognized sthenic relations.

It must, however, be kept in mind that the element of *size*, when used in the application of the principle, or as a mark of superiority, is not *absolute* size. For it is one of the laws of life that vegetative growth may enlarge a weak life-system to gigantic dimensions. Thus, the life-system of an Entomostracan takes great magnitude in a Limulus; of a Tetradecapod, in a female Bopyrus; of an Edentate, in a Megathere; of a Mutilate, in a Whale. The body of a Crab has 50 times the dimensions of that of an Insect; and its head probably 100 times that of the head of an Insect, although an Insect is the superior species.

Neither is mere muscular strength an indication of grade; for there is force used in sustaining the structure which is greater the higher the organism, and, superior to this, there is sensorial and other cephalic force. Were we to base our comparison between the grade of life-system in a Crab and that of a Bee on the ground of muscular strength, we should go far astray; and still wider from the mark, were we to rely on the relative sizes of the cephalic nervous masses; for this nervous mass in a common Crab (*Maia squinado* of European seas) has 25 to 30 times the bulk of that in a Bee. Man yields in size and muscular strength not only to the higher Megasthenes, but to the Whales or lowest; and the brain in the Elephant and the Whale outweighs his. The Megathere, although much more powerful than a Rodent, has not, on this account, as his structure and habits show, any claims to a place above the lowest of Microsthenes.

The terms *Megasthenes* and *Microsthenes* are not to be understood as signifying large Mammals and small Mammals, but Mammals of *strong life-system* and *weak life-system*. Comparing the typical species of Megasthenes[5] with those of Microsthenes,

[5] These orders of Mammals, (see last volume of this Journal, page 70, and page 342, beyond), make parallel series—the Chiropters or Bats of the Microsthenes representing the Quadrumanes of the Megasthenes, the Insectivores representing the Carnivores, the Rodents the Herbivores, and the Edentates the Mutilates.

there is some correspondence between average size of structure and strength of life-system. But a comparison of the typical of the former with the degradational of the latter leads to very false results.

An approximation to the right ratio is obtained from a comparison of the degradational species of each; but this is of no importance in its bearing on the question, since vegetative growth is apt to give the greatest proportional enlargement to the *lowest* species.

These facts teach that relative size of body, or of brain, is no necessary test of relative rank. The ratio, in *bulk*, of 1 : 3 between the brain of an average Man and that of a gorilla tells nothing of the actual difference of life-system, or of brain-power. At page 70, in the last volume of this Journal, the relative *lineal* dimensions of Microsthenes and Megasthenes is estimated at 1 : 4, which gives, for the relative *bulk*, 1 : 64. If this be the typical ratio between the life-systems of the highest Microsthenes and highest Megasthenes, surely that between the highest Megasthenes and normal Man—he constituting a *distinct order* (see p. 341)—must be at least as great.

The same ratio of 1 : 4, as shown by the writer, is that for the mean size, lineally, of Tetradecapods and Decapods, under Crustaceans. In two cases, then, consecutive orders differ by a like ratio, or approximately so, in dimensions. As has been remarked, deductions from mere size may be very erroneous; yet there is no reason, in either of the above cases, to suppose the ratio of life-systems less than that thus indicated. May not, therefore, some similar ratio exist between other analogous consecutive orders, where size does not manifest it,—as, for example, between Spiders and Insects? And is not the ratio a much greater one between the highest of Insecteans and highest of Crustaceans, since these subdivisions of Articulates are not orders but *classes?* Important results may flow from following out the idea here touched upon.

After the preceding explanations, I proceed to exhibit some of the relations of the higher groups in zoological classification, as they appear in the light of this subject of cephalization.

3. *Classification of Animals.*

1. *Subkingdoms.*—Of the four subkingdoms, first recognized by Cuvier and since by most zoologists, the Vertebrate, Articulate and Molluscan are typical, or of the true *animal-type*, and the Radiate is degradational, being *plant-like* in type. Using the terms alphatypic, betatypic and gammatypic *simply as a numbering of the grades* of types (see p. 334), their relations are as follows:

Alphatypic,	1. Vertebrates.
Betatypic,	2. Articulates.
Gammatypic,	3. Mollusks.
Degradational,	4. Radiates.

An important dynamical distinction between Mollusks and Articulates has been suggested on page 10 of this volume.

2. *Classes of Vertebrates, Articulates, Mollusks and Radiates.*—(1.) The classes of *Vertebrates* are four (see page 319), namely, Mammals, Birds, Reptiles and Fishes,—three of which are typical, of different grades, parallel with the above.

(2.) The classes of *Articulates* are but three, Insecteans, Crustaceans and Worms. This is illustrated at length at page 3 of this volume, where it is shown that the three divisions of Insecteans, namely Insects, Spiders and Myriapods, are distinguished by characteristics analogous to those which separate the divisions of Crustaceans,—Decapods, Tetradecapods and Entomostracans. The facts on this point are briefly presented on page 335. Insects and Spiders do not, in fact, differ more widely in external form or in structure than Decapods and Tetradecapods.

Insecteans and Birds express in different ways the same type-idea,—that of aerial life, Birds being flying Vertebrates and Insects flying Articulates; and, in accordance, they are of the same grade of type, both being *betatypic*. This follows, further, from the fact that there are but two grand divisions of Insecteans above the degradational division, that of Worms.

(3.) Among *Mollusks*, there are two well-characterized classes, the *first* including the *ordinary* Mollusks; the *second*, the *Ascidioids*, or the Brachiopods and Ascidians, which are mostly attached species and thus hemiphytoid. Besides these, there are the Bryozoans, which either make a third division under the Ascidioids (Edwards having long since pointed out their relations to the Ascidians); or they constitute a *third* class of Mollusks, characterized by being polyp-like both in external appearance and in being attached, and hence doubly hemiphytoid.

(4.) The *Radiates* are all degradational in their relations to the animal-type. But under the *Radiate-type*, the species of the first two classes are within type-limits, while those of the third are degradational, since almost all are attached and very inferior in type of structure, being the most phytoid of phytoid animals. The grades of structure as marked in the digestive system are as follows: (1) having approximately normal viscera, as in Echinoderms; (2) having, for the digestive system, only a stomach cavity, with vessels, imbedded in the tissues, radiating from it, as in Acalephs; (3) having, for the same, no system of viscera or radiating vessels; but only a central stomach surrounded by a cavity more or less divided at its sides by partitions, as in Polyps.

The following table presents the relations and the parallelisms of these classes, and of each to the subkingdoms.

	Subkingdoms.	Vertebrates.	Articulates.	Mollusks.	Radiates.
α.	Vertebrates.	Mammals.	———	———	———
β.	Articulates.	Birds.	Insecteans.	Ordinary.	Echinoderms.
γ.	Mollusks.	Reptiles.	Crustaceans.	Ascidioids.	Acalephs.
D.	Radiates.	Fishes.	Worms.	Bryozoans?	Polyps.

Arranging the divisions according to the relations of the groups to the *animal-type*, instead of the special type of each class, the table takes the following form:

	Subkingdoms.	Vertebrates.	Articulates.	Mollusks.	Radiates.
α.	Vertebrates.	Mammals.	———	———	———
β.	Articulates.	Birds.	Insecteans.	———	———
γ.	Mollusks.	Reptiles.	Crustaceans.	Ordinary.	———
a. D.	———	Fishes.	Worms.	Ascidioids.	———
b. "	———	———	———	Bryozoans.	———
c. "	Radiates.	———	———	———	Echinoderms.
d. "	———	———	———	———	Acalephs.
e. "	———	———	———	———	Polyps.

The letters *c*, *d*, *e*, stand for different grades of phytoid degradational, *b*, hemiphytoid, and *a*, degenerative. The blank interval between Mollusks and Radiates is filled up by the inferior divisions of the higher subkingdoms.

We may now consider the subdivisions under some of the classes; and first, those of Vertebrates.

3. *Higher subdivisions of the class of Mammals.*—The higher subdivisions of the class of Mammals are four in number: Man, Megasthenes, Microsthenes, and Oötocoids, as explained in the preceding volume of this Journal, p. 70 Man is shown to stand apart from the Megasthenes on precisely the same characteristic that separates the two highest orders under the classes severally of Insecteans and Crustaceans; for, in passing from Man to the brute Mammals, there is a transfer of the forelimbs from the cephalic to the locomotive series.

Moreover, a study of the Vertebrate skeleton has shown that the forelimbs in the Vertebrate-type, as well explained by Professor Owen, are *cephalic appendages*, being normally appendages to the posterior or occipital division of the head. In the Fish, these forelimbs (the pectoral fins) have at any rate an actual *cephalic position* (back of which position they are thrown, by displacement, in other Vertebrates). Now, in Man, they are not only cephalic in normal structural relations, but *cephalic* also in *use*. The transfer of these cephalic organs to the locomotive series, by which the brute structure is made, is a manifest degradation of the type. Man is thus the only Vertebrate in which the Vertebrate-type is expressed in its perfection, and therefore occupies *alone* the sublime summit of the system of life.

Three of the orders of Mammals, namely, Man, Megasthenes, and Microsthenes, are typical, of different grades, and one, Oötocoids, as explained on pages 316 and 332, is semidegradational.

For remarks on the *subdivisions* of Megasthenes and Microsthenes, see the articles above referred to, and also p. 338, preceding.

The Oötocoids may be divided into three groups—a *megasthenic*, a *microsthenic* and a *degradational;* the *first* to include the genera Phalangista, Dasyurus, Macropus, Diprotodon, etc.; the *second*, Perameles, Didelphys, Phascolomys, Echidna, etc., or Marsupial Insectivores, Rodents and Edentates; the *third*, Ornithorhynchus.

The following table presents to view the subdivisions of Mammals and its orders. Under Oötocoids, the relations of the two higher groups are indicated by the above adjectives, without giving them special names.

	Mammals.	Megasthenes.	Microsthenes.	Oötocoids.
α.	Man.	Quadrumanes.	Chiropters.	———
β.	Megasthenes.	Carnivores.	Insectivores.	Megasthenic.
γ.	Microsthenes.	Herbivores.	Rodents.	Microsthenic.
D.	Oötocoids.	Mutilates.	Edentates.	Ornithorhynchs.

4. *Higher subdivisions of the classes of Birds, Reptiles and Fishes.* —(1.) In the class of *Birds*, there are three grand divisions: the first two, as recognized by Bonaparte, are the *Altrices* (Rapacious birds, Perchers, &c., and other birds that feed their young until they can fly), and the *Præcoces* (or the Gallinæ, Anseres, Ostriches, etc., which feed themselves as soon as hatched). The third includes the Reptilian Birds or Erpetoids (p. 317). The terms *Pterosthenics* and *Podosthenics* apply equally well with *Altrices* and *Præcoces* to the two higher divisions of Birds, as explained on page 323, and have an advantage in their direct dynamical signification.

The type of ordinary Birds (or Pterosthenics and Podosthenics) is stated on page 333 to be essentially *limitate*, like that of Insects, while the type of Erpetoids is *multiplicate*, like that of Myriapods or of ordinary Reptiles; so that the relation of Erpetoids to the higher division of Birds is in an important respect analogous to that of Myriapods to the higher division of Insecteans.

(2.) In the classification of *Reptiles* there are three prominent types of structure recognized by Erpetologists; (1) that of the Chelonians; (2) that of the Lacertoids (including Saurians, Lizards, Snakes); and (3) the degradational or hemitypic one of Amphibians. It is now well known that Snakes and Lizards are alike in type of structure, the two groups graduating almost insensibly into one another, some species ranked as Lizards being

footless like the Snakes. The Snakes constitute the degradational group under the Lacertoids. The Amphibians, constituting the third order, are on the same level with the Erpetoid Birds and the Oötocoid Mammals, as presented in the following table.

The three orders of Reptiles—Chelonians, Lacertoids and Amphibians—make a parallel series with the three lower classes of Vertebrates; the Chelonians representing the Birds, to which they approximate in some points, besides being betatypic like them; the Amphibians representing the Fishes, with a still closer approximation between the two; while the Lacertoids are the typical Reptiles. The Chelonians might be viewed as *hemitypic* Reptiles; not *hypotypic* like the Amphibians, but *hypertypic*, like the Selachians and Ganoids among Fishes.

(3.) *Fishes* are all degradational species in their relations to the animal-type. The two higher groups, or those of Selachians and Ganoids as already explained (p. 334), are *hypertypic*. The third, including Teliosts, is *typical* if viewed with reference to the Fish-type. Below these, the Dermopters or Myzonts, (including Amphioxus, Myxine, etc.) constitute an inferior *hypotypic* or degradational group,—that is degradational in its relations to typical Fishes (p. 332). Thus *typical* Fishes are gammatypic in their relations to other Vertebrates, while the alphatypic and betatypic groups are *hypertypic* orders.

The following table exhibits the relations of the orders in the classes of Birds, Reptiles and Fishes; and, for comparison, those of Mammals are added.

	Mammals.	Birds.	Reptiles.	Fishes.
Alphatypic,	Man.	———	———	Selachians.
Betatypic,	Megasthenes.	Altrices, or Pterosthenics.	Chelonians.	Ganoids.
Gammatypic,	Microsthenes.	Præcoces, or Podosthenics.	Lacertoids.	Teliosts.
Hemitypic, or Degradational,	Oötocoids.	Erpetoids.	Amphibians.	Dermopters.

We pass now to Articulates.

5. *Subdivisions of the classes, Insecteans, Crustaceans and Worms into Orders.*—(1.) The higher subdivisions in each of the classes, *Insecteans* and *Crustaceans*, are three in number, none existing above the betatypic grade, which is that of Articulates among the subkingdoms, and of Insecteans among Articulates. (See page 7.)

(2.) *Worms* are of four types of structure. First, *Annelids*, or *typical* Worms, including the Branchiates, Abranchiates, and Nematoids—the last the degradational group, and showing this in the obsolete body-articulations and some internal characters.—Second, *Bdelloids*, or *Molluscoid* Worms, including the Hirudines or Leeches, Planarians and Trematodes; characterized by obso-

lescent or obsolete body-articulations, and by often wanting the nervous ganglia excepting the anterior; by usually a Gasteropod-like breadth and aspect, an *amplificate* feature; by being in general *urosthenic*, even the highest having a caudal disk for attachment; and in an up-and-down movement of the body in locomotion, *Mollusk-like*, instead of the worm-like lateral movement of the Annelids. The fact of this mode of movement has been recently made known to the writer by Dr. Wm. C. Minor, as a distinctive feature of the Bdelloids. Quatrefages remarks that the Planarians and Trematodes may well be regarded degraded forms of the Hirudines, and the three tribes are arranged in one group by Burmeister.—Third, *Gephyreans* (of de Quatrefages), or *Holothurioid* (*Radiate*-like) Worms, including the genera, Echiurus, Sipuncula, etc.[7]—Fourth, *Cestideans*, or *Protozoic* Worms, including the Cestoids, in which there is no normal digestive system, and the segments are independently self-nutrient.[8]

The orders of these classes of Articulates are the following:

	Insecteans.	Crustaceans.	Worms.
Alphatypic,			
Betatypic,	Insects.	Decapods.	Annelids.
Gammatypic,	Spiders.	Tetradecapods.	Bdelloids.
a. Degradational,	Myriapods.	Entomostracans.	Gephyreans.
b. "			Cestideans.

6. *Subdivisions of the orders of Insecteans and Crustaceans into tribes.*—(1.) The orders of *Insecteans* have each three divisions, excepting that of Myriapods in which but two have been recognized. The three of Insects are indicated on pages 323, 335. The fact that Insects are, in type-idea, *flying* Articulates gives special importance to the wings in classification. The *first* order includes the *Prosthenics*, in which the anterior wings are flying wings, as the Hymenopters, Dipters, Neuropters, Lepidopters and Homopters. The *second* consists of the *Metasthenics* or *Elytropters*, in which the anterior wings are not used in flying, or but little so, as the Coleopters, Strepsipters, Orthopters and Hemipters. The Hemipters and Homopters, united in one tribe by most entomologists, are hence profoundly distinct. The *third* tribe, or *Apters*, embraces the Lepismids and Podurellids; the remaining Apterous insects being distributed among the other

[7] The Holothurioid characteristics are well exhibited by de Quatrefages in Part ii, p. 248 and beyond, of *Recherches Anatomiques et Zoologiques faites pendant un voyage sur les Côtes de la Sicile, etc.*, in 3 vols. or parts, the second by de Quatrefages. Paris.

[8] The *Acanthocephali*, according to van Beneden and Blanchard, are Nematoids, (with which they agree in form and general structure) although without a digestive system. Blanchard states that there is reason for believing that the digestive system becomes atrophied with the growth of the animal, and mentions that cases of like atrophy occur even in species of *Gordius* and *Nemertes*.

groups, as suggested by different entomologists. The Lepismæ show their degradational character in their larval forms and in other approximations to the Myriapods, and the Podurellids appear to be still inferior in having the abdomen elliptic in some segments.

(2.) The orders of *Spiders* suggested by the principles of cephalization are in precise parallelism with those of the Decapod and Tetradecapod Crustaceans. They are, first, *Araneoids*, including all the *Pulmonates*, except the Pedipalps; second, *Scorpionoids*, or the Pedipalps from among the Pulmonates, and the Chelifer group from among the Trachearians; third, *Acaroids*.

The Araneoids are *Brachyural* Spiders; the Scorpionoids, *Macrural;* while the Acaroids are *degradational*. The last show their degradational character in having no division between the abdomen and cephalothorax; so that, while Insects have the body in *three* parts, head, thorax, and abdomen, and ordinary Spiders in *two*, cephalothorax, and abdomen, the Acaroids have it *undivided* (page 326). Thus, one of the most prominent characteristics marking the descent from Insects to Spiders becomes the characteristic of a further descent among Spiders themselves—illustrating a common principle with regard to such subdivisions. (See p. 350 beyond.) The propriety of making the Acaroids a distinct group appears therefore to be well sustained.

The usual subdivision of Spiders into Pulmonates and Trachearians depends on *internal* characters, which is not the fact with any other subdivisions in the table beyond. Moreover, these names, though *seeming* to mean much, are not based on any *functional* difference between the groups. Spiders have many relations to Crustaceans; and it is natural that the subdivisions in both should depend on the same methods of cephalization, the amplificative and analytic (p. 335).

(3.) The two orders of *Myriapods* are examples, one of case *a*, the other of case *b*, under multiplicative decephalization (p. 325).

The close relations between Isopods and the higher Myriapods, suggest that they are of like grade under their respective types, that is, betatypic.

(4.) *a*. Under *Decapod Crustaceans*, the subdivisions are *three*, as remarked upon by the author, at page 326 of this volume.*

The Anomurans are only degradational Brachyurans, and do not represent an independent type of structure. The Schizopods, similarly, are degradational Macrurans, with which they should be united. The *third* type is that of the *Gastrurans*, which are peculiar, among Decapods, in having the viscera extend into the abdomen, one of the marked degradational features of the type. They are the Stomapods of Latreille; but this author, in his last edition, made the group, in connection with the Schizopods,

* See also vol. xxv, [2], pp. 337, 338.

coördinate with that of Decapods. Being coördinate with Brachyurans and Macrurans, the change of name is necessary.

b. The *Tetradecapods* include two divisions precisely parallel with the first two of the Decapods, the first literally *brachyural*, the second *macrural*. (See p. 335 of this volume.) The *Anisopods*, of the writer, are degradational Isopods, just as the Anomurans are degradational Brachyurans. The Lemodipods (Caprellids, etc.) are only degradational Amphipods, the structure of the two being essentially the same in type. Hence, neither the Lemodipods nor the Anisopods are an independent type corresponding to a *third* subdivision.

The *third* subdivision probably is made up of *Trilobites*, although these are generally regarded as Entomostracans. One of the most prominent marks distinguishing Entomostracans from Tetradecapods is the absence of a series of abdominal appendages. It is highly improbable that the large abdominal (or caudal) plate of an Asaphus, or the many-jointed abdomen of a Paradoxides, Calymene, etc., should have been without foliaceous appendages below; and if these appendages were present, the species were essentially Tetradecapods, although degradational in the excessive number of body-segments.

c. Entomostracans (or Colopods, as they are more appropriately styled) embrace four orders. First, *Carcinoids* (as named by Latreille) consisting of the Cyclops group (Copepods of Edwards), whose species have a strong Macrural or shrimp-like habit; to which should be added the Caligoids, (Cormostomes of the writer, Siphonostomes of others,) since they are essentially identical in type of structure with the Cyclopoids, as may be seen on comparing *Sapphirina* of the latter with *Caligus*.—Second, *Ostracoids* (or the Daphnia, Cypris and Limnadia groups), which have, besides a bivalve carapax more or less complete, a much more elliptic abdomen than the Carcinoids, it being short, incurved, and without a lamellar terminal joint or terminal appendages.—Third, *Limuloids*, which have the abdomen still more elliptic, it being reduced to a mere spine, or nearly obsolete, and which have the mouth-organs all perfect feet and the only locomotive organs. (The joint across the carapax of the Limulus corresponds in position to a suture or imperfect articulation in the carapax of the Caligi, etc.)—Fourth, the *Rotifers*, a low Protozoic grade of degradation, in which all members are wanting, and locomotion is performed by cilia. The Phyllopods are distributed between the first two divisions.

The Rotifers are sometimes arranged under Worms. If they are degradational species of a limitate type, they are Crustaceans; and if of a multiplicate, they are Worms. The very small number of segments present, when any are distinct, the character of the dentate mandibles (for mandibles are *not* found

in the inferior subdivisions of Worms), and the resemblance in the form of some species to Daphniæ and other Entomostracans, sustain the view that they are Crustacean.

The Cirripeds appear to be only attached, amplificate Ostracoids. (See pages 324, 325.)

The subdivisions of the orders of Insecteans and Crustaceans are then the following:

	Insects.	Spiders.	Myriapods.	Decapods.	Tetradecap's.	Entomostr.
α.						
β.	Prosthenics or Ctenopters.	Araneoids.	Chilopods.	Brachyurans.	Isopods.	Carcinoids.
γ	Metasthenics or Elytropters.	Scorpionoids	Diplopods.	Macrurans.	Amphipods	Ostracoids.
a. D.	Apters.	Acaroids.	?	Gastrurans.	Trilobites.?	Limuloids.
b. D.						Rotifers.

7. *Subdivisions of the orders of the class of Worms.*—On the true method of grouping the typical (Branchiate and Abranchiate) Annelids, I here make no suggestions. The tribes of the other orders are probably those indicated on page 343, and which need not be here repeated. The Cystics are there included with the Cestoids. If any of the *simple* Cystics are really adults, they may possibly make a second subdivision of the Cestideans.

8. *Subdivisions of the classes of Mollusks.*—The Ordinary Mollusks include three orders, as usually given: (1) *Cephalopods*, (2) *Cephalates* and (3) *Acephals;* of which, the first two correspond to different grades of typical Mollusks, and the last is degradational in its relations to the type, the species being imperfect in the senses and means of locomotion.

The Ascidioid Mollusks comprise (1) *Brachiopods* and (2) *Ascidians*, with perhaps the *Bryozoans* as the *third* order. If the last, however, be made a third *class*, as suggested (though with hesitation) on page 340, there is no third order, unless the inferior of the compound Ascidians, having water-apertures to a *group* of individuals instead of to each one, and the mouth-opening of each usually *radiated* (the number of rays *six*), be regarded as the third. This would make the orders, (1) *Brachiopods;* (2) *Ascidians;* (3) *Incrustates;* the first two typical, the last degradational and strikingly hemiphytoid.

4. *Conclusions.*

The preceding review of zoological classification appears to sustain the following general conclusions.

1. *Number and typical relations of the subdivisions of groups.*

I. The number of subkingdoms, classes, orders, and tribes in the system of animal life is either *four* or *three*, that is, the division in each case is either *quaternate* or *ternate*.

II. The lowest of the subdivisions in each group is a degradational or semidegradational subdivision, or *hypotypic.*

III. The quaternate division is confind to *six* cases (excepting two or three among inferior types in which there are *two* degradational subdivisions): 1, the number of subkingdoms; 2, the number of classes under Vertebrates, the highest of the subkingdoms; 3, 4, the number of orders under Mammals and Fishes, the highest and lowest classes of Vertebrates; 5, 6, the numbers of tribes under two of the orders of Mammals.

IV. In *three* only of the six cases of *quaternate* division are the three higher subdivisions all *true typical*, namely; 1, in the division of the animal kingdom into subkingdoms; 2, of the Vertebrates into classes; 3, of Mammals into orders. In the last we reach Man. As man alone is archetypic in the class of Mammals (p. 334), so the Mammal-type is archetypic among Vertebrates, and the Vertebrate-type among the subkingdoms.

b. Below this archetypic level, in the orders of Mammals, the number of *true typical* subdivisions is but *two*—and these are the *betatypic* and *gammatypic;* for the first or alphatypic subdivision in both Megasthenes and Microsthenes, as explained on page 334, is *hypertypic*, and not true typical.

c. Again, of the *four* orders of Fishes only *one* is typical, the *two highest* being *hypertypic* (p. 334).

V. In the rest of the animal kingdom, the number of *true typical* groups, in the classes, orders and tribes that have been reviewed, is either *two*, the *betatypic* and *gammatypic*, or *one*, the *gammatypic* alone.

2. *Lines of gradation.*—Lines of gradation between groups are lines of convergence or approximation through intermediate species. Before mentioning under this head the deductions from the preceding classification (or VIII, and IX beyond), two general principles (VI and VII), having an important bearing upon them, are here introduced.

VI. The approximations between two groups usually take place, as has been frequently observed, through their *lower limits*, or most inferior species, that is, between the degradational subdivision of the inferior as well as of the superior group.—For example, plants and animals approximate only in their simplest species, the Protozoans and Protophytes; Birds and Quadrupeds most nearly in the Ornithorhynchus or Duckbill—which, at the same time that it is the lowest of Mammals, is related to a very inferior type of Birds, the Ducks; Quadrumanes and inferior Mammals through the Lemurs of the former and the Bats and Insectivores of the Microsthenes, and not through the higher Carnivores or even any of the Megasthenes.

The classes of Reptiles and Fishes may appear to be an exception. But the *Perennibranchs* (or the species with permanent gills) among Amphibians, if referred to the type of Fishes, and

especially to the Ganoid type, would rank low, as is obvious from their exsert and loosely-hung gills without gill-covers, the absence of scales, and the general inferiority in all structural arrangements. The Ganocephs, known only as fossils and generally regarded as Perennibranch Amphibians, have, it is true, a higher grade of organization, both as regards gills and scales, being allied, in these respects, to the highest of Ganoids. And this fact, in view of the above canon, sustains the opinion of Agassiz that the Ganocephs (or Archegosaurs) are actually Ganoids,—having a Reptilian feature in the partial elongation of the limbs, but in little that is fundamental in the structure beyond what belongs essentially to the Ganoid-type.

VII. The lines of gradation between classes, orders and tribes, are only approximating, not connecting, lines, there being often wide blanks of the most fundamental character. The Ornithorhynchus, although Duck-like in some points, leaves still a very wide unfilled gap between the Mammal and Bird, and the Marsupials a still wider. The species are fundamentally Mammalian, and Bird-like only in points of secondary importance. In a similar manner, there are long blanks between the Oötocoids and higher Mammals; between Myriapods and either Insects or Spiders; between Reptiles and Mammals. The intermediate groups belong decidedly to one or the other of the two approximating groups, and are never strictly intermediate.

VIII. Under any *class*, *order* or *tribe*, the lines of gradation run in most cases between the *degradational* subdivision and severally the *gammatypic* and *betatypic* subdivisions, and far less clearly, or not at all, between the gammatypic and betatypic themselves; that is, between D and γ, and D and β, rather than β and γ. For example, in the class of Mammals, the lines run between Oötocoids and either Megasthenes or Microsthenes, and not distinctly between Megasthenes and Microsthenes; in Insecteans, between Myriapods and either Insects or Spiders, and not distinctly between Insects and Spiders; in Crustaceans, between Entomostracans and either Decapods or Tetradecapods, and not distinctly between Decapods and Tetradecapods; etc. There are exceptions to the canon; and still it is a general truth.

IX. Under any *class* or *order* the line of gradation between the *degradational* and the *betatypic* subdivision (or D and β) is often more distinct than that between the *degradational* and *gammatypic*, (or D and γ), although the gammatypic is nearer in grade to the degradational.—Thus, the line between Myriapods and Insects is more distinct than that between Myriapods and Spiders; or that between Entomostracans and Decapods, than than that betweeen Entomostracans and Tetradecapods.

There is an exception in the class of Mammals: the Oötocoids seem to graduate towards both Microsthenes and Megasthenes with nearly equal distinctness.

3. *Coördinate grades and distinctions in Classification.*

X. The coördinate value of subdivisions in the system of classification is brought out to view in the parallel columns of the preceding tables, and evidence is thence afforded as to what groups are rightly designated, classes, orders, etc.

a. We thus learn that the subdivisions of the class of Mammals—Man, Megasthenes, Microsthenes,—are properly *orders*, if we so call the subdivisions Decapods and Tetradecapods under Crustaceans, or Insects and Spiders under Insecteans.

b. Again, we have a solution of the question whether in each of the classes, Mammals, Birds, and Reptiles, the *hemitypic* division, as so-called on page 316, is a *subclass* coördinate with the *typical* division of the same, *or* whether it is an *order* coördinate with the three higher subdivisions of the class. The question appears to be decided, (contrary to former views of the writer,) that it is correctly made an *order*. These hemitypic divisions actually correspond severally to the degradational division in other columns of the different tables; and, therefore, if in the case of other classes, as those of Crustaceans, Insecteans, &c., they are *orders*, so are they in the three classes of Vertebrates mentioned. They have also a relation to the *hemitypic* divisions among Fishes, which are the first and second *orders* of the class.

XI. In an *inferior* or *degradational* group, the distinctions of the subdivisions included are generally much more strongly and obviously exhibited in the structure than among *typical* groups. Thus, the orders of Fishes are based on characters that have nearly a class-value among the higher Vertebrates. In the same manner, Amphibians, or hemitypic Reptiles, differ from true Reptiles more obviously than Oötocoids, or hemitypic Mammals, differ from other Mammals. So, the distinctions among the groups of Crustaceans are very wide compared with those among Insects; and those among degradational Crustaceans far wider than those among the typical subdivisions. The relative force of the life-systems is, in all probability, as great between Oötocoids and typical Mammals as between Amphibians and typical Reptiles, although so unequally expressed in the structure of the high or concentrated groups and the low or lax groups of species. Overlooking this principle has often led authors to allow too great importance to the structural differences among inferior or degradational groups.

XII. Under any class, order, tribe, the *typical* groups are often represented more or less clearly among the subdivisions of the *degradational*. Hence characteristics which separate the typical groups frequently separate only subordinate divisions under an inferior or degradational group. Examples occur in the class of Fishes under Vertebrates, in whose subdivisions the other classes of Vertebrates are partly represented; in the order

of Oötocoids under Mammals, which has its megasthenic and microsthenic subdivisions; under Worms, etc.

4. *Distinction between Animals and Plants.*

XIII. This subject well illustrates a fundamental distinction between animals and plants.

a. An animal, as has been stated on page 332, has *fore-and-aft*, or antero-posterior, polarity; that is, it has a fore-extremity and a hind-extremity which have that degree of oppositeness that characterizes polarity.

b. With this fore-and-aft polarity there is also *dorso-ventral* polarity.

c. The dorso-ventral and antero-posterior axes are at *right angles* to one another. In Invertebrates and a large part of Vertebrates the antero-posterior axis is horizontal and the dorso-ventral vertical; and only in Man, the prince of Mammals, is the former vertical and the latter horizontal.

d. An animal, again, has not only oppositeness between the fore-extremity and hind-extremity, but also a *head*, the seat of the senses and mouth, situated at the fore-extremity and constituting this extremity.

e. In addition, the typical animal is *forward moving.*

But in animals of the inferior type of *Radiates,* while there is an anterior and a posterior side, and also, in most species, forward motion, the mouth-aperture—which indicates the *primary centre* in an animal (p. 322)—is not placed at one extremity, but is more or less nearly *central*; and almost precisely central in the symmetrical (and therefore inferior) Radiates. The mouth-extremity and the opposite are at *the poles of the dorso-ventral axis*, and not at those of the antero-posterior; that is, they are at the extremity of the axis which in the inferior animals is normally *vertical.* This is true even in a Holothuria, the mouth of which is not at the *anterior* extremity, but is central, or nearly so, as in an Echinus. A Limulus has been referred to on page 328 as showing an approximation, under the true animal type, to this same central position of the mouth.

We pass now to *Plants.* The plant, in contrast with the fore-and-aft animal, is an *up-and-down* structure, having up-and-down polarity. The axis is *vertical* like the dorso-ventral in the lower animals, to which it is strictly analogous, as is shown from a comparison with Radiates,—Radiates and Plants being alike in type of structure. The primary centre of force is central, in the same sense, in the regular flower and the symmetrical Radiate.

Thus, the structures under the animal-type and plant-type are based on two distinct axial directions, one at right angles to the other: in the *animal-type* the antero-posterior axis being the dominant one, while the two coexist; and in the *plant-type* the axis at right angles to this being the only one.

In the above way, (as well as in its non-percipient nature,) the plant exhibits complete decephalization—a condition to which the Radiate only approximates, as it has generally, if not always, an anterior and posterior side, besides other animal characteristics.

Note to page 327.—The term elliptic, as used on page 327, implies defectiveness or deficiency of parts *through abnormal weakness* in an organ or the general system. The foot of the horse, one of the examples mentioned, is therefore hardly elliptic, since it has its full normal strength in the one toe, this being enlarged at the expense of the others. Paragraph *a* and the second under *b* hence require correction accordingly. In the fifteenth line from the foot of the page, Animal-type should be Mammal-type.

ART. XXX.—*On vibrating Water-falls;* by ELIAS LOOMIS, Professor of Natural Philosophy and Astronomy in Yale College.

IN the year 1843, I published in this Journal, vol. xlv, p. 360, a notice of several water-falls which at times exhibited very strong vibratory motion. I am not aware that any one else had ever published anything on this subject previous to that time. In that article, I proposed an explanation of these vibrations, which was naturally suggested by the only case which I had myself had an opportunity to investigate; viz., that the dam itself was the vibrating body, and that the vibrations were analogous to those of a stretched cord. The attention of several other observers has since been called to the same subject, and Prof. Snell has endeavored to show that the vibrating body is the column of air behind the sheet of water, and that the time of vibration depends upon the length of this column. I have thus been led to examine the subject anew, and have been compelled to modify the views which I first published. I have made a large number of observations on several different water-falls, and have obtained numerous observations made by other persons. These observations have been made chiefly at three places, viz: at South Natick, Mass.; at Holyoke, Mass.; and at Lawrence, Mass.

Observations at South Natick, Mass.

In August, 1859, Mr. William Edwards communicated to me the results of numerous observations which he had made upon a water-fall at South Natick, Mass., about 18 miles west of Boston. The dam over which the water fell, consisted of two separate portions. One of them, the northern, was 98 feet long and 9 feet high, built of hewn timbers generally about 10 inches square, framed together, and banked up with earth to within

three feet of the edge. Mr. Edwards, who resided near the dam, had determined that

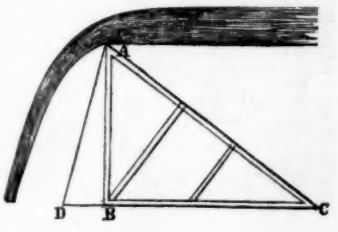
When the height of the water on the edge of the dam was		the number of vibrations was	
	10 inches,		280 per minute.
	8 "		300 "
	7 "		335 "
	5 "		over 400 "

I at once perceived that these numbers indicated a general law; viz., that *the time of one vibration is nearly equal to the time in which a heavy body would fall through a space equal to the depth of water on the dam.* This will appear from the following table, in which column first shows the depth of water on the edge of the dam; column second shows the time of one vibration expressed in fractions of a second; and column third shows the time which a heavy body would require to fall through the spaces in column first, and is computed by the formula $t = \sqrt{\frac{2s}{g}}$. Column fourth shows the quotients obtained by dividing the numbers in column second by those in column third.

Depth of water.	Time of one vibration.	Time of falling through depth.	Ratio.
10 inches.	0s·214	0s·228	0·940
8 "	0 ·200	0 ·204	0·982
7 "	0 ·179	0 ·190	0·940
5 "	less than 0 ·150	0 ·161	less than 0·932

In April, 1861, a portion of this dam, about 70 feet in length, was carried away, and was rebuilt during the following summer. The new part of the dam is of the same height as the old one, and is boarded up tight in front at a slope of about 75°; but the old part, being about 30 feet in length, is open in front as formerly. In the annexed figure,

1.



AB represents the height of the dam, AC the slope inclined against the stream, and AD shows how the new part is boarded up on the lower side. Formerly, the space behind the sheet of water was entirely free, back to AC, with the exception of the interruption caused by the beams which supported the dam. Now when the water is only 5 inches deep, the descending sheet strikes AD within about 12 inches of the bottom. There is a square stone abutment on the south side of the sheet, and it is boarded up with planks on the north side, so that the air behind the sheet of water is almost completely enclosed.

The south dam is 100 feet long, and 9 feet high, and boarded up in front at a slope such that with a depth of 8 inches of water,

the descending sheet strikes the sloping boards nearly in the middle of their height. The south dam is quite old and its edge is rough, so that the vibrations are never very regular or strong. The north dam is the one upon which Mr. Edwards' observations have all been made.

In the spring of 1863, Mr. Edwards, at my request, made a more extended series of observations, measuring accurately the depth of water on the edge of the dam, and counting the corresponding number of vibrations. The depth of water was measured by inserting a small rod 4 inches from the edge of the dam. Mr. Edwards states that, at a distance of 20 rods above the dam, the water was $1\frac{1}{4}$ inches higher than at the point where he measured it. The following table shows the results of Mr. Edwards' observations in 1863, and is deduced from numerous trials between April 23 and May 4.

Depth of water.	Time of one vibration.	Time of falling through depth.	Ratio.
9·21 inches.	0ˢ·220	0ˢ·218	1·007
8·12 "	0 ·192	0 ·205	·937
7·00 "	0 ·177	0 ·190	·930
6·31 "	0 ·164	0 ·181	·906
5·06 "	0 ·138	0 ·162	·850

These results differ sensibly from those deduced from Mr. Edwards' first series of observations. The difference may be ascribed in part to the greater accuracy of the last observations, since fractions of an inch were disregarded in the first measurements. Perhaps also something is due to the modification in the structure of the dam. I am however inclined to think that the influence of the latter cause is slight, and that the discrepancies are mainly due to the unavoidable imperfection of such observations. Any one who shall attempt to repeat these observations, instead of complaining that Mr. Edwards' results are not perfect, will probably be surprised at the precision which he has actually attained.

The result, then, which we deduce from these observations at South Natick, is that *the time of one vibration is a little less than the time in which a heavy body would fall through a space equal to the depth of water on the dam;* and this deficiency increases as the depth of water diminishes.

Observations at Holyoke, Mass.

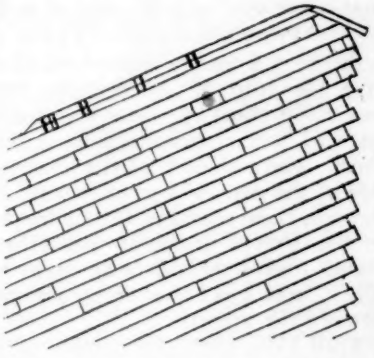
The dam across the Connecticut river at Holyoke, Mass., is 1017 feet long and 30 feet high. It is formed of square timbers, inclined 22 degrees to the horizon, having one end bolted to the rock, and the other resting upon a timber frame-work. From the crest of the dam, the water descends along an apron about four feet in length, which slopes downwards at an angle

of 22 degrees. Professor Snell has observed the vibrations at six different times, and with the following average results (this Journal, vol. xxviii, p. 229).

When the water on the edge of the dam is	1 foot in height,	the number of vibrations is	$257\frac{1}{2}$ per minute.
	2 feet "		$137\frac{2}{3}$ "
	5 feet "		82 "

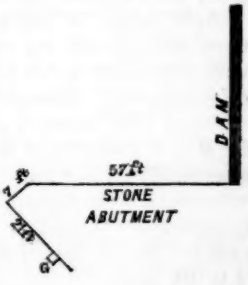
I have spent considerable time at Holyoke, for the purpose of determining the number of vibrations corresponding to different depths of water. I visited the place in August, 1859, but there were only 6 inches of water on the crest of the dam, and the vibrations were not noticeable. I obtained the engineer's plan of the dam, from which the annexed figure has been reduced on a scale of $\frac{1}{12}$ inch to a foot. In July, 1860, I spent several days in observations, during which time the depth of water ranged from two feet to one foot; and again in April, 1861, when I saw the water on the crest of the dam increase from 43 inches to 100 inches. The vibrations ceased altogether after the water had risen to 76 inches. I also made a few observations in July, 1861.

2.



To indicate the depth of water, there is a gauge, graduated to feet and inches, placed 60 feet from the crest of the dam, and firmly secured to the stone abutment. The annexed plan will show the position of the gauge with reference to the dam. The figure represents the stone abutment on the west side of the dam, together with a small portion of the dam. The position of the gauge is indicated by the letter G. At each of my observations, I recorded the depth of water by this gauge; and when the water was not more than two feet deep, I measured it directly on the crest by means of a pole. When the depth was too great to allow this mode of measurement, I measured the difference of level between the surface of the water at the gauge,

3.



and on the crest, by comparing it with the top line of the abutment, which appeared to have been levelled with considerable care. In this manner it was found that when the depth, as shown by the gauge, was 97½ inches, the depth on the crest was 15 inches less. The following table exhibits the average of a considerable number of comparisons.

Depth by gauge.	Depth on crest.	Difference.
14·75 inches.	12·25 inches.	2·5 inches.
16·5 "	13·5 "	3 "
23 "	19 "	4 "
97·5 "	82·5 "	15 "

For depths less than two feet, the depression of water on the crest of the dam is 0·175 of the depth by the gauge; but for a depth of 8 feet, the depression is 0·154 of the depth by the gauge. From these results, I have deduced the depth of water on the crest from the indications of the gauge.

On the 10th of April, 1861, the vibratory motion of the descending sheet of water was through a space of one or two feet, and was synchronous from one end of the dam to the other. Through each of the abutments, and on a line with the edge of the dam, is a passage way, 2½ feet wide and 7 feet high. Through these passages, the air frequently flows with great force. On the 10th of April, at each vibration of the sheet of water, the air rushed through with great violence towards the waterfall. There was however no *outward* motion, but simply a lull between the vibrations.

April 11th, 1861, the motion of the sheet was greatest near the middle, but was very noticeable throughout the whole length. There was no wind of any consequence. Depth of water by the gauge 4 ft. 0½ inch.

April 12th, the vibrations were exceedingly strong, with a fresh breeze from the south. Gauge 4 ft. 3½ in.

April 13th, in the morning, the vibrations were sometimes very strong, and then soon afterward moderate, with frequent variations, the wind blowing in gusts from the south with a drizzling rain. Gauge 4 ft. 5¼ in.

April 13th, toward evening, the vibrations were very strong for 6 or 8 times, then feeble for about as many more; and so on, alternately strong and feeble. Near the middle of the sheet, the vibrations were tolerably regular; but towards either extremity, it appeared inclined to stop, and seemed to be forced into vibration by the power of the middle portion of the sheet. Gauge 4 ft. 9½ in.

April 14th, 1861, the vibrations had ceased entirely. Gauge 6 ft. 8 inches.

April 15th, the sheet of water was extremely smooth, without the slightest sign of vibrations. Through the passage way in

the abutment on the east side of the river, the air flowed in a strong and steady breeze without pulsations. There was a slight breeze from the northwest. Gauge 8 ft. $2\frac{3}{4}$ inches.

April 16th, the sheet of water was tolerably smooth without the slightest appearance of periodical vibrations. Gauge 7 ft. $10\frac{3}{4}$ inches.

Thus it will be seen that when the gauge indicated 4 ft. $9\frac{1}{2}$ inches, the vibrations were becoming irregular; and when the water rose to 6 ft. 8 in. the vibrations ceased entirely. As this rise of the water occurred in the night, it was impossible to determine the exact depth of water at which the vibrations ceased.

The following table presents a summary of all my observations at Holyoke.

Prof. Loomis' observations at Holyoke.

Date.	Depth of water by gauge.	No. of vibrations per minute.	Temperature of water.	Date.	Depth of water by gauge.	No. of vibrations per minute.	Temperature of water.
1859, Aug. 16	6 inches.	0		1860, July 7	28 inches.	135·4	
1861, July 30	14 "	257·0	$73\frac{1}{2}°$	1861, Apr. 10	47 "	81·6	$43\frac{1}{2}°$
" July 31	$14\frac{1}{4}$ "	256·6		" Apr. 11	$48\frac{1}{2}$ "	81·2	
1860, July 10	16 "	254·9	73	" Apr. 12	$50\frac{3}{4}$ "	80·8	43
" July 9	17 "	249·2		" Apr. 12	$51\frac{1}{2}$ "	80·9	
" July 9	18 "	256·0		" Apr. 13	54 "	80·0	
" July 8	23 "	134·4		" Apr. 13	$57\frac{1}{2}$ "	78·6	
" July 8	25 "	134·8		" Apr. 14	80 "	0	43

Mr. Joseph P. Buckland, a graduate of Yale College, who resides at Holyoke, has at my request made a series of observations, of which the following is a summary.

Date.	Depth by gauge.	Vibrations per minute.	Date.	Depth by gauge.	Vibrations per minute.
1862	ft. in.		1862	ft. in.	
Sept. 22	1 $10\frac{1}{2}$	308 nearly.	Sept. 10	2 $5\frac{1}{2}$	128
" 21	1 $10\frac{1}{2}$	288 or 290	" 6	2 6	133
" 9	1 $11\frac{1}{2}$	296 or 298	" 4	2 7	128
Aug. 31	2 0	280	" 5	2 $7\frac{1}{2}$	134
Sept. 1	2 0	280	" 5	2 $7\frac{3}{4}$	133
" 9	2 $\frac{1}{4}$	292	" 2	2 $8\frac{1}{2}$	133
" 8	2 $2\frac{1}{4}$	273	" 3	2 $10\frac{1}{2}$	130

It will be perceived that my observations, for depths from 14 to 18 inches, agree pretty well with Prof. Snell's, as stated on page 355; but Mr. Buckland differs materially from both of us. No one, without trying it, can properly appreciate the difficulty of estimating the number of these vibrations when they exceed four per second; and I am of opinion that Mr. Buckland has estimated the velocities for depths from 22 to 26 inches, considerably too great. For depths a little greater than two feet, we all agree reasonably well.

It must be considered as sufficiently established by these observations, that the sheet of water at Holyoke exhibits three

different rates of vibration, viz., about 256, 135, and 81 vibrations per minute, corresponding to depths of 16, 28 and 56 inches of water on the dam. The change from the first to the second rate of vibration, takes place when the depth of water is from 23 to 26 inches; and the change from the second rate to the third, takes place when the depth is from 35 to 47 inches. The vibrations are not noticed when the depth of water is less than about 12 inches, and they also disappear when the depth is as great as 80 inches.

Moreover, for either of these modes of vibration, the number of vibrations per minute is not absolutely constant. On account of the discrepancies in the observations, this proposition may not be considered as fully established for the two more rapid modes of vibration; but for the slower mode of vibration the proof is unequivocal. The observations from April 10th to 13th, 1861, were very numerous, and were made with great care, and the vibrations were so slow that they could be counted with almost as great precision as those of an ordinary seconds' pendulum. The number of vibrations per minute dimishes as the depth of water increases from 47 to 57 inches. This effect is of the same kind as that observed at South Natick, but the quantity of the effect is much less.

In order to reduce, as far as possible, the influence of the errors of observation, and to diminish the labor of calculation, I have divided my observations into four groups, and taken the average of the depths of water, as well as of the times of vibration. The first group includes the observed depths less than 20 inches; group second includes the observed depths from 20 to 40 inches; group third, the depths from 40 to 51 inches; and group fourth, the depths from 51 to 60 inches. The results are as follows:

Depth of water by gauge.	No. of vibrations per minute.	Temperature of the water.	Observed time of one vibration.
15·90 inches.	254·74	73°	0s·236
25·33 "	134·87	73	·445
48·75 "	81·20	43	·739
54·33 "	79·83	43	·752

It is evident, from the motion of the air through the passage way in the abutment at the east end of the dam, that the air behind the sheet of water vibrates simultaneously with the sheet. Is it possible to explain the preceding observations on the supposition that the time of one vibration depends simply upon this column of air? The column of air behind the sheet of water is 1017 feet long; its height April 12, 1861, was about 28 feet, and its average thickness was perhaps 8 feet. The temperature of the air behind the sheet is assumed to have been that of the water, viz: 43°. The velocity of sound at this temperature is 1098 feet per second.

A column of air 1017 feet long, and having a very small diameter, would make one vibration in $\left(\frac{1017}{1098}=\right)0^{s}\cdot926$. According to experiments with organ pipes, the length of the column in this formula should be increased by some function of the breadth, generally about twice its breadth. If we increase the length of the column of air by the sum of the height and thickness, we shall have for the computed time of one vibration $\left(\frac{1053}{1098}=\right)0^{s}\cdot959$. Either of these quantities exceeds the time actually observed, by about one-fourth of the latter quantity.

It appears, from experiments with organ pipes of different forms and with different embouchures, that the time of one vibration varies considerably according to the mode in which the impulse is communicated to the column of air; but I do not know of any established principle which will explain how a column of air, having the dimensions of that at Holyoke, should make one vibration in three-fourths of a second, whether it vibrates as one mass, or as two separate portions. The change in the number of vibrations, when the depth of water increases from 48 to 54 inches, indicates that the time of one vibration does not depend solely upon the dimensions of the column of air; and this motion has the appearance of a constrained vibration, depending upon two causes which separately would produce vibration in unequal times. I have therefore computed the time of one vibration, first upon the supposition that the air is the only vibrating body, and secondly upon the supposition that the vibrations originate in the sheet of water, according to the law indicated by the observations at South Natick.

Depth by gauge.	Depth on crest = D.	Observed time of vibration.	Vibration of air computed.	Time of falling through D.
15·90	13·12	$0^{s}\cdot236$	$0^{s}\cdot232$	$0^{s}\cdot261$
25·33	20·90	·445	·463	·329
48·75	40·63	·739	·959	·459
54·33	45·28	·752	·959	·484

In the preceding table, column I shows the depth of water in inches according to the gauge; column II shows the depth on the crest of the dam, determined according to the principles explained on page 356; column III shows the observed time of one vibration; column IV shows the time of one vibration of a column of air 1017 feet long, computed in the manner explained above; the air in the first case being supposed to be divided into four vibrating portions, and in the second case into two portions; and column V shows the time in which a heavy body would fall through the spaces given in column II.

It will be noticed that the observed time of vibration in each case falls between the times computed by these two methods.

Observations at Lawrence, Mass.

The dam at Lawrence is 900 feet long, and has an average height of 34 feet. It is in the form of an arc of a circle whose radius is 7433 feet; and the versed sine of the arc is therefore nearly 14 feet. It is built of hewn stone, consisting of large blocks, accurately fitted to each other.

Sixty-five feet from the south side of the river, is a fish way 30 feet wide, which effectually divides the falling sheet of water, cutting off 95 feet of the dam. The portion of the sheet of water which is entirely free, cannot exceed 805 feet in length.

Stout bars of iron about three feet long, are inserted in holes drilled in the top stones, at intervals of 3 or 4 feet, and these support a row of planks called flash boards, which raise the water 18 inches higher than the stone work of the dam. These planks are put up in June, and remain until they are carried off by the spring or winter freshets. Until these planks are carried away, the vibrations are never noticed.

I have obtained the coöperation of an excellent observer at Lawrence, viz: Mr. Benjamin Coolidge, engineer of the Essex Manufacturing Company, who has watched the dam for several years, and has made careful observations at my request. The following is a summary of his results:

In the spring of 1860, there was no freshet, and no vibrations were noticed upon the sheet of water.

In the spring of 1861, the vibrations were observed as follows:

March 5th. 100 vibrations in 37½ seconds. Depth of water 3·63 feet.

March 11th. 100 vibrations in 37½ seconds. Depth of water 3·41 feet.

April 1st. 100 vibrations in 37¼ seconds. Depth of water 3·12 feet.

The flash boards were on the north end of the dam, for about 60 feet; thence for 40 feet mostly gone. At the south end of the 40 feet, the vibrations began and continued to the fish weir, which gives about 700 feet of vibrating fall. The vibrations made a distinct noise that could be heard pulsating above the roar of the fall.

April 16th. 100 vibrations in 51 seconds. The depth of water on the edge of the crest-stone was 5 feet. Perhaps there were some 50 feet more of vibrating over-fall than on the 1st of April.

April 20th. 160 vibrations per minute. Water on the crest-stone 3·08 feet. Temperature of water 44° F. Temperature of air 46°. As near as I could judge, the length of the vibrating sheet was very nearly 780 feet, and very much the strongest in the middle of the sheet. The rush of air at the north end of the sheet (the only one open to observation) was very strong,

and followed the vibration of the sheet, but with a continuous inward draft.

In the spring of 1862, the following observations were made.

April 18. 162 vibrations per minute. Depth of water 5 feet. Thermometer 44°. These vibrations were for 200 feet at north end of dam, alternating with vibrations in middle of dam.

April 19. 134½ vibrations per minute. Depth of water 5 feet. Therm. 42°.

April 21. 136 vibrations per minute. Depth of water 5 feet. Therm. 42°.

April 26. 156½ vibrations per minute. Depth of water 3·18 feet. Therm. 43°.

May 5. 150 vibrations per minute. Depth of water 3·25 feet. Therm. 49°.

May 6. 154 vibrations per minute. Depth of water 2·95 feet. Therm. 50 deg.

April 18, 1863, Mr. Coolidge observed the number of vibrations to be 122 per minute, and the depth of water 5½ feet measured on the crest of the dam.

The following table presents a summary of

Mr. Coolidge's observations at Lawrence, Mass.

Date.	Depth of water.	Observed time of one vibration.	Date.	Depth of water.	Observed time of one vibration
1862, May 6	2·95 feet.	0ˢ·390	1861, March 5	3·63 feet.	0ˢ·375
1861, April 20	3·08 "	·375	" April 16	5·00 "	·510
" April 1	3·12 "	·372	1862, April 18	5·00 "	·370
1862, April 26	3·18 "	·383	" April 19	5·00 "	·446
" May 5	3·25 "	·400	" April 21	5·00 "	·441
1861, March 11	3·41 "	·375	1863, April 18	5·50 "	·492

The first seven of these observations agree with each other about as well as such observations usually do. The mean of these seven observations gives a depth of 3·23 feet, and the corresponding time of vibration is 0ˢ·381.

The observations of April 16, 1861, and April 18, 1862, differ very widely. I can only ascribe the discordance to the effect of flash boards which had not been carried away, and which created openings in the descending sheet of water. I have therefore thought best to take the mean of the last five observations, which gives the time of one vibration 0ˢ·452, corresponding to a depth of 5·10 feet.

I visited Lawrence in August, 1859, and again in August, 1861, but the depth of water at these times was not sufficient to produce vibration. In April, 1863, I had the good fortune to witness the vibrations with considerable force. I found it very difficult to count the number of vibrations satisfactorily. For a few seconds, the pulsations would be very marked, and then they would often become so faint as to be noticed with difficulty, so that it was generally impossible to follow them for an entire

minute very satisfactorily. The descending sheet of water was very uneven, being marked by numerous ridges, probably caused by the flash boards having been only partially carried away. I spent two days in almost constant attempts to count the vibrations, and my result was an average of 148·68 vibrations per minute, corresponding to a depth of 4·41 feet water by the gauge. If we reduce this depth according to the rule determined at Holyoke, it would give a depth of 3·68 feet on the crest of the dam; but according to Mr. Coolidge's measurements, it would indicate a depth of exactly 3 feet on the crest of the dam.

Comparing all these observations, they seem to favor the conclusion that the time of one vibration increases as the depth of water on the dam increases; but the discrepancies are so great that even this conclusion might be called in question, if it were not confirmed by the observations at South Natick. If we take an indiscriminate mean of all the observations, we find the average time of one vibration to be 0ˢ·409, corresponding to a depth of water on the crest of the dam amounting to 4 feet, and a temperature of the water 44°.

A column of air 805 feet in length, 30 feet high, and 7 feet wide, according to the principles stated on page 359, would make one vibration in 0ˢ·766; or if it vibrated in two portions, the time would be 0ˢ·383. A heavy body would fall through a space of 4 feet in 0ˢ·499. The observed time is intermediate between the times computed by these two methods.

It seems impossible to explain all the preceding observations upon the supposition that the air behind the sheet of water is the sole vibrating body, following the laws which have been established in the case of organ pipes. The observations at South Natick naturally suggest the idea that the vibrations originate in the sheet of water itself; the time of one vibration being nearly proportional to the square root of the depth of water on the dam.

Is there any known principle which will enable us to explain vibrations of this description?

It has been suggested that such vibrations may originate in the unequal velocity of the upper and lower strata of the sheet of water which pours over the dam. If there were no friction, the lower stratum should have a velocity equal to that which a heavy body would acquire in falling through a space equal to the height of the water above the dam. The upper stratum has only the velocity of the stream, combined with that which is imparted by the motion of the lower stratum. The lower stratum (if it could move independently) would describe a parabolic path, which could be computed from the depth of water on the dam. But the upper stratum acts as a load, forcing the lower stratum to describe a path more nearly vertical. The descending sheet of water is therefore in a condition of equilibrium, resulting from

the superior momentum of the under part of the sheet, balanced by the weight of the upper part. Suppose now that from any external cause (for example a puff of air) the sheet is forced back beyond the position of equilibrium, the instant this force ceases to act, the momentum of the under part of the sheet forces the entire mass forward, and its inertia carries it beyond the position of equilibrium. The weight of the upper part of the sheet forces it again backward; and thus it has been supposed there might result a series of vibratory movements.

It seems difficult, however, upon this theory, to account for the nearly isochronous, long continued and powerful vibrations which we actually observe.

It has been suggested that this vibratory motion originates in the column of air behind the sheet of water, while the water serves merely as a load, to retard the velocity of these vibrations. The column of air behind the sheet of water at South Natick, is of such dimensions that it should make one vibration in about one-tenth of a second. When the depth of water is 5 inches, the observed time of vibration is $0^s{\cdot}038$ greater than the computed time of an air vibration; but with a depth of 10 inches the observed time is $0^s{\cdot}114$ greater than the computed time.

When an elastic string is loaded, the time of one vibration varies as the square root of the load. At South Natick, when the depth of water increases from 5 to 10 inches, the increase in the time of a vibration seems to be even more rapid than the increase in the depth of water.

At Holyoke, when the depth of water is 45 inches (if we suppose the air to vibrate as one mass) the observed time of vibration is less than the computed time for a column of air without any load, which appears impossible according to this theory. If we suppose the column of air to be divided into two vibrating segments, the time of an air vibration is $0^s{\cdot}480$, while the observed time is $0^s{\cdot}272$ greater than this.

When the depth of water is 40 inches, the observed time is $0^s{\cdot}259$ greater than that of an air vibration.

When the depth of water is 21 inches, (if we suppose there are only two vibrating segments), the time of an air vibration is $0^s{\cdot}465$, while the observed time is a little less than this; which seems impossible upon the present theory. If we suppose there are three vibrating segments, the time of an air vibration is $0^s{\cdot}310$; while the observed time is $0^s{\cdot}135$ greater than this.

When the depth of water is 13 inches, (if we suppose there are four vibrating segments) the computed time of an air vibration, is $0^s{\cdot}232$, while the observed time is only $0^s{\cdot}004$ greater than this. If we suppose five vibrating segments, the time of an air vibration is $0^s{\cdot}186$, while the observed time is $0^s{\cdot}050$ greater than this. If we suppose six vibrating segments, the

observed time is $0^s{\cdot}081$ greater than the computed time of an air vibration.

At Lawrence, (if we suppose there are only two vibrating segments,) the time of an air vibration is $0^s{\cdot}383$, while the observed time exceeds this by only $0^s{\cdot}026$. If we suppose there are three vibrating segments, the time of an air vibration is $0^s{\cdot}255$, and the observed time exceeds this by $0^s{\cdot}154$. If we suppose there are four vibrating segments, the observed time is $0^s{\cdot}218$ greater than the computed time of an air vibration. If we suppose there are six vibrating segments, the observed time is $0^s{\cdot}281$ greater than the computed time of an air vibration.

If now we compare the results obtained at these three localities, we shall find that we may make such a supposition with regard to the number of vibrating segments into which the column of air divides itself, that the apparent retarding effect of the water shall be nearly proportional to the thickness of the sheet. The following table presents a summary of these results.

	Depth of water — D.	Observed time of one vibration.	Number of vibrating segments supposed.	Computed time of an air vibration.	Retardation produced by water — R.	Quotients. $\frac{R}{D}$
South Natick	5·06 inches.	$0^s{\cdot}138$	1	$0^s{\cdot}100$	$0^s{\cdot}038$	·0075
	10·00 "	0·214	1	0·100	0·114	·0114
Holyoke	13·12 "	0·236	6	0·155	0·081	·0062
	20·90 "	0·445	3	0·310	0·135	·0064
	40·63 "	0·739	2	0·480	0·259	·0064
	45·28 "	0·752	2	0·480	0·272	·0060
Lawrence	48·00 "	0·409	4	0·191	0·218	·0045
	48·00 "	0·409	6	0·128	0·281	·0059

Column fourth shows the computed time of an air vibration, when the number of vibrating segments is assumed as in column third; column fifth shows the difference between the numbers in columns second and fourth, being the retarding effect of the sheet of water according to the theory under examination; and column sixth shows the quotients obtained by dividing the numbers in column fifth, by the numbers in column first. These quotients, with one exception, are nearly constant, indicating that the retarding effect of the sheet of water is nearly proportional to its thickness. The exception to this general rule which occurs at South Natick, may perhaps be ascribed to the small height of the fall, in consequence of which, especially when the water is high, the descending sheet acquires somewhat of the rigidity of a solid body.

The number of vibrating segments of the column of air, is the principal unknown quantity which renders our conclusions so very uncertain. I do not know of any theory which will enable us to compute the precise influence of a sheet of water of given dimensions; but at present, it seems probable that the vibratory motion originates in the column of air behind the sheet of water,

and that the descending sheet serves merely as a load, to retard the velocity of these vibrations.

This theory will be fully established or disproved, when we are able to compute the effect produced upon the vibrations of a column of air, by a descending sheet of water of given dimensions.

Why are not these vibrations noticed wherever water pours over a dam?

It is believed that most water-falls exhibit some degree of vibratory motion at certain stages of water; but in order that these vibrations may be powerful and long-continued, the edge of the dam must be horizontal, and quite smooth; otherwise the thickness of the descending sheet will not be uniform; and the sheet will swell into ridges in some places, while other parts become thin. The sheet will divide in some places before reaching the bottom of the fall, and this leaves an opening in the enclosure which contains the column of vibrating air.

This is probably the reason why many water-falls never exhibit this phenomenon in a palpable manner; and why in only a few cases is the vibration so powerful as to cause any annoyance.

Why is a particular height of water requisite to produce these vibrations?

The descending sheet of water must have a thickness of several inches; otherwise it is divided by the action of the air, and the column of air ceases to be enclosed on all sides. With a fall of nine feet, as at South Natick, a thickness of 4 or 5 inches is requisite; and with a fall of 30 feet, as at Holyoke, a thickness of nearly a foot is requisite. At Lawrence, with a fall of 34 feet, the vibrations are not noticed when the depth of water is much less than 3 feet; but this seems to be owing to the inequalities on the top of the dam, resulting from the iron bars being bent over by the spring freshets, and confining some of the flash boards to the top of the dam.

The vibrations cease almost entirely when the water exceeds a certain height, because the thickness of the sheet becomes too great in comparison with its height, and there being some cohesion between the particles of the liquid, the sheet partakes somewhat of the rigidity of a solid body. In order to produce a strong effect, the thickness of the sheet must not exceed about one-sixth or one-eighth of the height of the fall. At South Natick, with a fall of 9 feet, which is somewhat diminished by the back water at the time of a freshet, the vibrations cease when the depth of water much exceeds ten inches. At Holyoke, with a fall of 30 feet, which is also diminished by the back water at the time of a freshet, the vibrations cease when the depth of water much exceeds 5 feet. At Lawrence also, where the fall is a little greater than at Holyoke, the vibrations cease when the depth of water on the crest of the dam much exceeds five feet.

ART. XXXI.—*On the Rocks of the Quebec Group at Point Lévis*, (being a letter to Mr. JOACHIM BARRANDE of France, from Sir WILLIAM E. LOGAN, Canadian Geological Survey.)[1]

Montreal, 15th March, 1863.

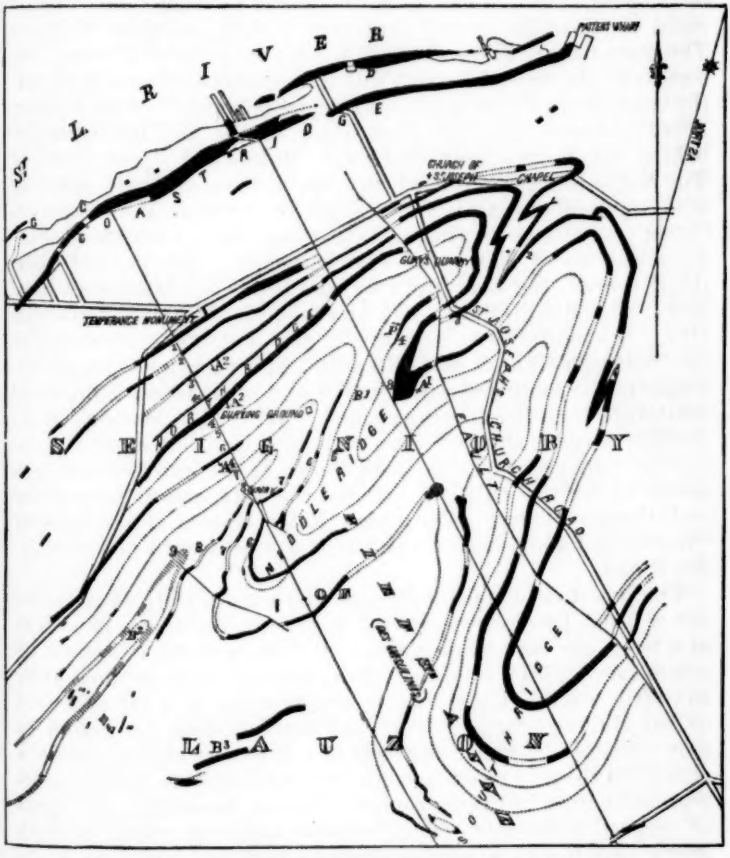
MY DEAR MR. BARRANDE,—*Mr. Jules Marcou* has addressed to you a letter dated the 2d August, 1862, on the Taconic rocks of Vermont and Canada, in which he says, on page 10, "I was able this year to follow out and trace every bed and layer on the whole contour of Point Lévis, from the Grand Trunk Terminus to Indian Cove; and as Point Lévis is a point of land surrounded by high cliffs, I feel satisfied that there is no repetition of beds, and no synclinal axis; and that the few foldings of the strata at Ferry's cliff are mere accident, confined to a distance of a few feet, and are without any effect upon the whole mass of strata, but are what we call in French *structure ployée* (contorted strata)." On page 14 he says: "Fearing that my first unsuccessful attempt last year to understand the explanation of Messrs. Logan and Billings might be my own fault, I tried very hard this year again, when at Point Lévis, but with no better success, and I left the point, fully convinced that the fossils described by Mr. Billings, and the so-called outcrops, A^2,A^3,A^4, &c. of Mr. Logan, were collected and observed in a very careless way, without regard to stratigraphy, by irresponsible collectors, or by unskillful practical geologists."

I have neither time nor inclination for controversial geology. I have never criticised any of Mr. Marcou's remarks on rocks in Canada, or out of it, nor have I suggested any such criticisms to others; but a charge of carelessness on the part of public officers in the discharge of their duties appears to me, on the present occasion, to require a few words of reply, lest you and others might suppose the accusation to have some foundation. It is due to Mr. Marcou to give him credit for the very great care he claims, as I am persuaded he would not have ventured so unreservedly and condemnatory a contradiction of what has been stated on the part of the Survey, without having exhausted all his skill on his own investigation. The only critical remark therefore left me to make, is that this distinguished stratigraphist has been very unfortunate; and that having missed the main feature of the conspicuously marked structure he so carefully searched for, it is not surprising that he should find a difficulty in understanding a statement connected with it.

In 1854 and 1856, a considerable time was expended by Mr. Richardson, one of my assistants, and myself, in ascertaining by

[1] Communicated to this Journal by Sir WM. E. LOGAN.

measurement the position and extent of all the exposures of the limestone conglomerates which characterize Point Lévis. The result of this work was exhibited by me to Mr. Marcou, at the office of the Survey, in 1861, on an unpublished manuscript map, on a scale of six inches to one mile, showing nearly all the known exposures of rocks of the Quebec group for about twenty miles below, twenty miles above, and nearly twenty miles to the south-eastward of Quebec. This map represents an area of 800 square



Plan showing the distribution of limestone conglomerates at Point Lévis.

miles, on which all the exposures are laid down by admeasurements, comprising the work of one member of the Survey for two seasons, and of another for one season. The measurements at Point Lévis I have recently re-protracted on the same scale,

with a view of completely separating what is exposed to view, from what is inferred; and a plan reduced from this to one half, by photography, accompanies the present communication.[2] The topographical as well as the geological features are delineated from the measurements of the Survey.

On this plan, the heavy black bands represent the known exposures of the limestone conglomerates; the dotted lines between different exposures represent their supposed connection. Some of the geographical undulations are shown by what I have designated the Coast Ridge, and the North, Middle and South Ridges. The main feature of the Coast Ridge is a thick band of limestone conglomerate extending in a hill and precipice, which overlook the beach from Patten's wharf to the neighborhood of the Lower Ferry; beyond which it gives place to the cliff immediately behind the houses near the Lower, Middle and Upper Ferries. The North Ridge is a hill which rises up from, and runs parallel with, the road passing in front of the Temperance Monument or Cross; and attains its greatest height in a band of limestone-conglomerate about 300 yards southeastward. The part of this ridge nearest the road probably constitutes Mr. Marcou's Cross Hill. The Middle Ridge, is, I presume, Mr. Marcou's Parochial Hill. It includes Guay's quarry, or the Redoute, and crossing the St Joseph Church road (Route de l'Eglise), extends for about a mile to the southwestward, with a somewhat broad depression southward from the Burying-ground. Where Mr. Marcou's Middle Hill may be situated, I am not quite sure, but suppose it to be the upper part of my North Ridge, as the extension of this seems to be the only hill between the Temperance Monument and Guay's quarry. The South Ridge crosses the St. Joseph Church road about half a mile to the southeastward of the Middle Ridge.

The limestone conglomerates, as you are probably aware, consist of beds of yellow-weathering magnesian limestone, in which, as a base, are embedded masses of pure compact limestone, of colors varying from yellowish-white, through gray and brownish, to nearly black. These masses are generally of a sub-spherical or sub-elliptical form, looking like boulders, and many of them may probably be such; but beds of a limestone almost precisely similar to them in character appear occasionally to run in an irregular manner in the conglomerate bands, presenting the aspect of original sediments. The yellow-weathering matrix is often arenaceous, the white silicious grains sometimes attaining a quarter of an inch in diameter. The bands of conglomerate are separated from one another by greenish and blackish slates, which, in many places, are interstratified with strong yellow-

[2] The essential portion of the map referred to is reproduced on the accompanying woodcut without change of scale.—Eds.

weathering gray and black calcareo-magnesian slates, and occasionally with yellow-weathering sandstones. In a few places, red slates are intermingled with the others.

Southeastward from the St. Lawrence, the limestone conglomerates of Point Lévis are distributed over a breadth of more than two miles. In the North Ridge, there are four bands, numbered 1, 2, 3, 4, on the map; on which is represented, in addition, a long lenticular bed (4^a) subordinate to 4, but separated from it by slate. The lenticular bed is composed of brown-weathering magnesian limestone, but appears to contain few or no enclosed masses of the pure limestone. The bands 3 and 4 are, respectively, A^2 and A^3 of a former description. You will perceive that northeastwardly they converge a little; and at the time of that description, it was not determined whether they were to be considered two distinct beds, or one a repetition of the other. They are now taken to be two distinct beds. Followed northeastwardly, they appear to be dislocated by a fault near the St. Joseph Church road; but beyond this they are easily traceable around the extremity of a trough, with a deep channel worn between them in the slate. After passing the axis of the synclinal, the band 4 comes to the limestone of Guay's quarry, which is nothing more than a large lenticular mass of pure limestone, subordinate to the band. Southwestward of the quarry, both bands are seen again crossing the St. Joseph Church road, and again coming against the transverse fault. This fault appears to show an upthrow on its southwest side; since on that side the opposite outcrops of the trough are thrown towards the centre.

Continuing to trace the outcrops on the southern side of the trough, that of band 4 gradually thins, and disappears at P, in less than a furlong; while that of the band 3 becomes more conspicuous, and shows a great development as it folds over an anticlinal axis just eastward of the eastern boundary of the fief Ste. Anne. From this it returns towards the Church road, but becomes concealed about fifty yards before reaching it, after again showing the effect of the fault, in a much smaller horizontal displacement than before. On the northeast side of the anticlinal axis, on both sides of the fault, the dip is to the southeastward, and is therefore overturned; but from the character of the displacement, it is evident that beneath the surface, on the northeast side of the fault, the inversion must be compensated for by a change to the northwest in the slope.

A little above the outcrop of band 4, at P, there occurs a layer of sandstone, which is traceable on the fief Ste. Anne over the anticlinal axis; and a sandstone approaches the outcrop of band 3 at A^1. In the description of 1860, this was supposed to show that possibly the stratigraphical place of the band 4 might

gradually approach the band 3, and finally merge into it; but finding farther on, along the outcrops, an exposure of conglomerate at *z*, which will answer for band 4, it is now conceived that there may be two layers of sandstone, one above and the other below the stratigraphical place of band 4; and though this band thins to nothing at P, it may commence again in its relative place farther on.

From the neighborhood of the Temperance Monument, the outcrop of band 2 is traceable northeastward, running not quite parallel with 3, to the fault, and thence across the St. Joseph Church road to the main road. It traverses this obliquely, a little beyond the church, and its turn upon the synclinal axis is seen on the north side of the road, about 400 yards beyond. In the limestone of Guay's quarry there is a small notch-like turn, which serves to augment somewhat its apparent volume; a corresponding twist is more conspicuous in the outcrop of band 3, and in band 2 it assumes a still further prominence at *y*. These successive forms indicate a plait in the stratification, commencing at the quarry, and rapidly augmenting northeastwardly in the space of 350 yards. The importance of its effect on the distribution of the strata would, at this rate of increase, soon become considerable, and it serves to show some of the complications of the neighborhood.

Without going into detail, it is evident from the map that the Middle Ridge is an anticlinal form, and that the South Ridge is another. On this, the exposures of the bands 2 and 3 conspicuously mark the turn on the axis, as they do in the synclinal between the ridges. It will be perceived that, between the synclinal and anticlinal axes, the outcrop of band 2 is represented as showing a very sharp twist. The evidence of this is not quite satisfactory, and the apparent arrangement may possibly be due only to a swelling in the volume of the band, with parts obscured by drift.

The Temperance Monument stands on band 1, with which are associated some layers of sandstone. This band is easily traced to the northeastward across the fief Ste. Anne; but between that and the fault it becomes broken down and obscured, and it will require further investigation. Nothing like it, nor indeed any conglomerate band, has been yet observed following, in its relative place, the sinuosities of band 2, where the strata are affected by the synclinals and anticlinals that have been described. Eastward of the fault and northward of band 2, there is an exposure of conglomerate close upon the southeast side of the main road; the bearing of which would carry it under the church of St. Joseph, and two years ago it was observed in an excavation for the foundation of a house on the northwest side of the road, close by the church. In the strike of these expo-

sures, about 400 yards beyond the church there is a band of conglomerate, which continues in the same strike for about a hundred yards. This strike would carry the band away from those of the North Ridge, and gradually bring it towards those of the Coast Ridge, and it appears probable that the bands of the Coast Ridge may be only a repetition of some of those of the North Ridge. The main band of the Coast Ridge is associated with several beds of sandstone; and, from its great breadth, it may possibly be capable of division into more than one mass of conglomerate. To the southwestward of the extreme point to which this band has been traced, there occurs in the cliff, to the southeast of the Lower Ferry, the band A; one of those referred to in the description of 1860. Its exact relation to the other bands has not yet been satisfactorily determined.

Southward of A^3 you will remark A^4, and you will perceive that these two bands somewhat converge to the southwest, in which direction they are not traceable for over a quarter of a mile. At the time of the previous description, it was left undecided whether these were to be considered distinct bands, or a repetition of one another. They are now assumed to be distinct. On the Middle Ridge, the band 4, at P, is followed by B^1; which is a band of slate with nodules of limestone. On the North Ridge, its place would be between A^3 and A^4. It would therefore be band 5, and A^4 would be band 6. The bands 7, 8, and 9 succeed on the north side of the Middle Ridge, the band 9 being B^2 of the former description; like B^1, it is composed of slate studded with nodules of limestone. This band appears to have a considerable development southwestwardly, in a long shallow trough-like form, extending to the Grand Côte road. From this, its outcrop returns on the south side of the Middle Ridge anticlinal, and points to B^3; which however differs from it in character, having a base of magnesian limestone instead of slate. What is seen of the band B^3 is broken into three portions by transverse faults. It is evidently on the south side of the Middle Ridge anticlinal, and may correspond with band 8, but this has not yet been satisfactorily made out; nor has it yet been found possible to arrange the complicated exposures to the southeast of it, on the South Ridge.

On the southwest boundary of the fief Ste. Anne, near the quarry there indicated, the beds appear to be dislocated on the north side of the Middle Ridge anticlinal, by faults, which do not affect the outcrops on the south side. These faults may be small breaks accompanying twists in the strata, the connecting parts of which may be concealed by drift; but it would require additional facts to make their arrangements certain. Though the number of bands is assumed to be nine, some of them may be repetitions through the effect of plaits suddenly starting up,

like that at *y*, or through undetected faults running with the stratification. The distribution of the outcrops in the southwest part of the South Ridge shows the very complicated character of the disturbances, and is a warning against over-confidence in respect to minute details. In regard to the main features of the structure however, there appears to be no doubt; namely, that the Middle and South Ridges are two well marked anticlinals, and that a synclinal, not less so, runs between the Middle and North Ridges, repeating the whole mass of strata.

From the foregoing explanations, you will be able to understand how the fossils enumerated in the description of 1860 are related to the conglomerate bands, as represented on the map. The whole of these fossils were collected by the officers of the Survey, who are all perfectly aware of the importance of observing the exact stratigraphical place of the organic remains, and always most carefully do so. The collectors were Messrs. Billings, Richardson, Bell, and myself; and, from the statements made to me by my colleagues and assistants, I am quite prepared to assert that the specimens referred to B^3, B^2, B^1, A, A^1, and A^3, are from the bands marked on the map by those letters. With the exception of a single specimen of the pygidium of *Bathyurus Saffordi*, obtained by Mr. T. Sterry Hunt from the band 4 (A^3), where it crosses the more northern synclinal axis near the Redoute, the band A^2 afforded to my late regretted and talented young scientific friend, Mr. John Head, and myself, the first collection of fossils obtained by the Survey at Point Lévis. These were taken from the whitish limestone masses associated with the bed, where it crosses the fief Ste. Anne, and the opinion in regard to them expressed by Mr. Billings induced me to instruct Mr. Bell to make a further collection on the same band. In addition to the fossils collected by Mr. Head and myself from the band, there are some by Mr. Richardson, and others by Mr. Bell, all from the fixed rock; but in Mr. Bell's collection there are, in addition, those from the limestones designated by Mr. Billings as Nos. 1 and 3. These limestones were not, like the rest, firmly attached to the band, and as they have been by Mr. Marcou designated as two loose boulders, lying on the superficial soil, while he carries them away from their true site, and approximates their position to the lime-kiln of the Redoute, in order to affiliate them to that mass, it will be necessary for me to describe their mode of occurrence.

On the fief Ste. Anne, the band 3 (A^2) dips to the southeast at a high angle. It is from about twenty to twenty-five feet thick, and in its calcareo-magnesian base it holds a great many masses of yellowish-white limestone, in which fossils are apparent and somewhat abundant. It is underlaid by slates; and in some parts a sudden step to the underlying slates occurs at its

northern edge. At the foot of this step, Mr. Bell observed in one place a mass of gray-weathering yellowish-white limestone protruding for a few inches through the soil. This mass, when excavated from its position, proved to be about a foot in diameter, and very fossiliferous. Persuaded that it had fallen from the conglomerate band, he tried farther on in the strike and found another; and, finally, in the distance of about fifty feet along the strike, he obtained five masses, each as heavy as would require a strong man to lift, and twelve smaller masses, each of about twenty pounds weight and upwards. They were all rich in fossils. Some of these gave to Mr. Billings his limestone No. 1, and others that of No. 3. All of these masses, some of which were sharply angular, rested on the slate, just at the base of the conglomerate band; and, with the exception of the small portion of the first one, were wholly covered by the soil, one of them to the thickness of a foot, requiring, before it could be extracted by aid of pick, shovel, and crow-bar, a hole to be made of two feet deep. It appears to me much more probable that these masses should have fallen from the conglomerate band which they touched, than that they should have been transported nearly half a mile from the Redoute, and all laid at the foot of the conglomerate band A^2, in a row in its strike. It is by no means supposed that the stock of these masses was exhausted by Mr. Bell; more may probably be obtained in the strike, and I am persuaded that, if the adjacent parts of the conglomerate band were laid bare, similar masses would be found imbedded in it.

Mr. Marcou states that the limestones Nos. 1 and 3 without doubt come from the Redoute; and that in respect to No. 1, so rich in trilobites, he could almost point out the exact spot from which it came. Soon after the first discovery of fossils at Point Lévis, I spent a good deal of time in endeavoring to obtain specimens from Guay's quarry, but with very indifferent success. Fragments of trilobites were observed, but the only recognizable species obtained was *Menocephalus globosus*. Perceiving that Mr. Marcou had been so fortunate as to meet with upwards of nine species of trilobites in the locality, I last season renewed my attempt; and, with Mr. Billings, made a diligent search of the rock, but with no better luck than had attended my previous researches—*Menocephalus globosus* being again the only species procured. Mr. Marcou states that the stratification is indistinct, and that in consequence of the hardness of the stone, it is difficult to obtain specimens. This perfectly accords with what we observed; but not with the characters of the limestones Nos. 1 and 3; which are not very hard, and in which the fossils occur in layers, marking well the stratification. The limestones split with moderate facility in the direction of those layers, and

give considerable planes of surface, with fossils starting prominently up from them. I presume, therefore, that the beds at the Redoute, with which Mr. Marcou compares the limestones No. 1 and 3, are some which he has not yet described, and with which we can make no comparison, as we have not been so fortunate as to find them.

Since 1860, Mr. Devine and Mr. Cayley, both of the Crown Lands Department, have obtained several species at Point Lévis. The latter gentleman discovered *Amphion Cayleyi* (Billings) in band 3 (A^3), on the North Ridge; and Mr. Devine, on the same ridge, has procured *Bathyurus Saffordi* from band 2, *Menocephalus globosus*, and *Cheirurus Eryx* from band 3 (A^3); and from band 4 (A^4) *Bathyurus Saffordi*, *B. Cordai*, and *B. bituberculatus*. But from this band he has made a very important addition to the fauna of Point Lévis, in a perfect specimen of what Mr. Billings agrees with him in considering an *Oienus*, or of a closely allied genus. This was obtained on the North Ridge, just east of the fief Ste. Anne, in a mass of drab-colored limestone, which Mr. Devine thinks is a part of the solid band, although he has not yet tested the matter sufficiently to be positive. The same part of this band here holds *Obolella*, *Orthis Evadne*, *Camerella Calcifera*, *Pleurotomaria*, *Ecculiomphalus Canadensis*, *Orthoceras*, *Agnostus Americanus*, *A. Canadensis*, *A. Orion*, *Arionellus subclavatus*, *Bathyurus capax*, *B. quadratus*, *B. Saffordi*, *Cheirurus Eryx*, *C. Apollo*, *Dikelocephalus magnificus*, *D. megalops*, *D. planifrons*, *D. Oweni*, *Menocephalus Sedgwickii*, and *M. Salteri*. In this collection, the species of *Pleurotomaria*, *Ecculiomphalus*, and *Cheirurus* do not occur in the same hand-specimens of rock with the others. *Bathyurus Saffordi* is in the same specimen with *Menocephalus Salteri*. On the Middle Ridge, he has obtained *Menocephalus globosus* from band 4, at the Redoute. Mr. Billings has obtained in band 2, on the North Ridge, *Bathyurus quadratus;* on the Middle Ridge, in band 6, on the north side of the anticlinal, *Leptæna decipiens;* and the same species in band 7, on the same side of the anticlinal; while band 7, on the south side of the anticlinal, has yielded him a *Pleurotomaria*, allied to *P. Laurentiana*, *Orthoceras*, *n. s.*, *Illœnus* ———, and *Asaphus* ———. In a band of conglomerate forming two successive mounds at the water's edge, northwest of the Coast Ridge and running parallel with it, he has met at D with a new species of *Dikelocephalus*.

To make the distribution of the fossils, which we in Canada (including Mr. Devine and Mr. Cayley) have obtained at Point Lévis, more clearly understood, a catalogue of them has been prepared, with the specific names of those which have been described and a separate column for each of the bands, and made a part of the present communication. In this catalogue, no certain stratigraphical place is assigned to the bands D, G, and A,

in relation to the others—which, from 1 to 9, are supposed to be in ascending order. With the exception of those otherwise marked, all the determined species have been described by Mr. Billings.

Mr. Marcou, it appears to me, has gone somewhat out of his way to insinuate a discourtesy towards you on the part of the Canadian Survey, in that we have, as he says, distributed fossils of the Quebec group in England to more favored geologists than yourself. Mr. Marcou could not have stated this from his own knowledge, as it is not consistent with fact. The truth of the matter is precisely the reverse of this. We long ago did ourselves the pleasure of transmitting to you a small collection of the principal species; while we have presented none to any other of our geological friends in Europe. On this side of the Atlantic, we have exchanged a few specimens with Col. Jewett, of the New York State Museum, for New York species, of which we stood greatly in want; and we are just now about to make a small exchange with Mr. A. H. Worthen, State-geologist of Illinois, for species from several of the Western States, of which we have long been anxious to possess authentic specimens. Mr. Marcou seems especially aggrieved that he did not obtain a pygidium of *Dikelocephalus magnificus*, asked for, as he states, in your name. This was during my absence in England at the International Exhibition. Mr. Billings cannot call to his recollection that the application was made in your name. Such an application would have afforded him the opportunity of informing Mr. Marcou that you were probably already supplied in the collection sent; but it would not have altered the propriety of what, in conformity with his duty, he found himself under the necessity of replying; namely, that he was not authorized to distribute the specimens of the Provincial Collection.

I am, my dear Mr. Barrande, yours very truly,

W. E. Logan.

Mr. Joachim Barrande, Rue Mezière No. 6, Paris.

Catalogue of Fossils from the Quebec Group, collected at Point Lévis.

	D	G	A	1	2	3	4	5	6	7	8	9
Tetradium?.....		*										
Graptolithus, *several sub-genera* (Hall)		*					*					
Lingula Mantelli.....						*	*					
" Irene.....		*										
" Quebecensis			*									
Obolella Ida.....						*	*					
" desiderata			*									
Acrotreta *n. s.*						*						
Leptæna decipiens								*	*	*	*	*
" sordida								*				

	D	G	A	1	2	3	4	5	6	7	8	9
Leptæna, *undescribed* 1.								*				
" " 2.						*						
" " 3.							*					
Strophomena, *undescribed*			*									
Orthis gemmicula								*				
" Tritonia								*				
" orthambonites (Pander)								*				
" Euryone								*				
" Electra								*				
" Hippolyte								*				
" Evadne								*				
" Mycale								*				
" Eudocia								*				
" Quebecensis			*									
" *undescribed* 1.						*						
" " 2.							*					
" " 3.							*					
" " 4.												*
Camerella Calcifera						*	*					
Stricklandia? Arachne								*				
" Arethusa								*				
Cyrtodonta? *undescribed*								*				
Ecculiomphalus Canadensis							*	*				
" intortus							*					
Pleurotomaria vagrans							*					
" Postumia							*					
" Quebecensis							*					
" *undescribed* 1.							*	*				
" " 2.							*					
" " 3.											*	
" " 4.											*	
Murchisonia, *undescribed*, 1.							*					
" " 2.							*					
" " 3.							*					
" " 4.											*	
Helicotoma perstriata							*					
Ophileta uniangulata (Hall)							*					
" *undescribed*, 1.							*					
" " 2.							*					
Maclurea Atlantica											*	
Holopea dilucula (Hall)							*					
" *undescribed*							*					
Metoptoma Melissa							*					
" Hyrie							*					
" Orphyne							*					
" Venillia						*	*					
" anomala							*					
Metoptoma Augusta							*					
" superba							*					

	D	G	A	1	2	3	4	5	6	7	8	9
Orthoceras Autolycus							*					
" *undescribed* 1.							*					
" " 2.							*					
" " 3.							*					
" " 4.							*					
" " 5.							*					
" " 6.												*
Cyrtoceras Metellus							*					
" Dictys							*					
" Alethes							*					
" Mercurius							*					*
" Syphax												
" *undescribed*							*					
Nautilus "												*
Agnostus Americanus						*	*					
" Orion						*	*					
Agnostus Canadensis						*	*					
Amphion Cayleyi						*	*					
Ampyx, *undescribed*							*					
Arionellus cylindricus						*						
" subclavatus						*						
Asaphus Illænoides						*						
" goniurus						*	*					
Bathyurus capax						*						
" dubius						*						
" bituberculatus						*						
" armatus						*	*					
" Saffordi							*					
" oblongus							*					
" Cordai							*					
" quadratus					*		*					
Cheirurus Apollo							*					
" Eryx							*					
Conocephalites Zenkeri						*	*					
Dikelocephalus magnificus						*	*					
" planifrons						*	*					
" Oweni						*						
" Belli						*	*					
" megalops						*						
" cristatus						*						
" *undescribed*	*											
" (Olenus) Logani (Devine)							*					
Endymion Meeki											*	
Holometopus Angelini											*	
Illænus, *undescribed*											*	
Leperditia											*	
Menocephalus globosus						*	*					
" Sedgwicki						*	*					
" Salteri (Devine)							*					
Nileus, *undescribed*							*				*	
Shumardia granulosa				*								

ART. XXXII.—*Chauvenet's Manual of Spherical and Practical Astronomy.*[1]

[SECOND NOTICE.]

THE publication of this work opens a new era for the student of astronomical science. Henceforth, the study of spherical and practical astronomy is a very different thing from what it has been with all the aids previously existing in the English, French and German languages. That these assertions may not seem exaggerated, we propose to give a somewhat detailed account of those parts of the work which are original with the author, and which we think of sufficient importance to establish the truth of our assertions.

Chapter I, on Spherical and Rectangular Coördinates, initiates the student into the method of applying spherical trigonometry to astronomical problems, in the most general manner. The expressions for the rectangular coördinates of a point in space, in terms of the distance of the point from the origin and of the spherical coördinates, are deduced in a new and extremely simple way.

Chapter II, on Time and the use of the Ephemeris, is unusually complete on various minor points which are apt to embarrass beginners—such as the conversion of mean or apparent solar time into sidereal time; the deduction of local time from the given hour angle of any celestial body, and the inverse problems; the management of interpolation formulas in consulting the ephemeris, etc.—with all of which the young astronomer must be perfectly familiar before he can proceed.

Chapter III, on the Figure of the Earth, does not treat the methods of determining the earth's figure, which is left to geodesy, but gives the geodetic formulas, with their demonstration, which are necessary to the astronomer in reducing observations to the centre of the earth. Bessel's dimensions of the terrestrial spheroid are adopted. The author has not forgotten to notice the "abnormal deviations of the plumb line," which render it necessary to distinguish between the *astronomical* and the *geodetic* latitude or longitude of a point on the earth's surface; deviations which were first pointed out and also accurately determined by our own admirable Coast Survey. Now that the existence of such deviations is established, and the method of eliminating them pointed out, it is certainly desirable that a new measurement of the earth's dimensions should be entered upon by the leading nations of the world. It can hardly be doubted that the earth will be found to differ sensibly from an

[1] A Manual of Spherical and Practical Astronomy. By WILLIAM CHAUVENET, LL.D., Chancellor of Washington University, St. Louis, Mo. Published by J. B. Lippincott & Co., Philadelphia.

ellipsoid of revolution, but it may be expected that, by eliminating as far as possible the anomalous deviations in question, with the aid of the elements determined by Bessel, a very close approximation to the true figure will be obtained.

Chapter IV, on the Reduction of Observations to the Centre of the Earth, another preliminary chapter, is almost exhaustive upon the subjects of Parallax, Refraction, Dip of the Horizon, etc. The author presents the whole of Bessel's theory of refraction (based upon Kramp's and Laplace's) in a most lucid and masterly manner. A complete view of the present state of the refraction theory, however, requires a consideration of Ivory's investigations at least, to say nothing of those of Plana and others; but it would, perhaps, have occupied too large a space in the work before us. Mr. Chauvenet adopts Bessel's Tables, as thus far agreeing best with observation, and therefore limits himself to an explanation of the principles by which that table is constructed. We notice that the author has deduced from theoretical considerations a formula for the dip of the horizon, including the effect of refraction, which agrees remarkably with the results of actual observation. The effect of refraction upon the figure of the discs of the sun and moon is also investigated.

Chapter V, on Finding the Time by Astronomical Observations, brings us fairly into the subject of practical astronomy, to which the preceding chapters are but introductory. This, together with Chapter VI, on Finding the Latitude, and Chapter VII, on Finding the Longitude by astronomical observations, appears to embrace every previously known method of any value, with several new and simple methods, and is accompanied by numerous practical precepts which are designed to inculcate accurate habits of observation and precision in computation. Of the many approximative methods of "working a lunar distance," which have heretofore been given, Prof. Chauvenet gives but one, and that is his own. Any one who will take the trouble to read the investigation of the formulas upon which his method rests, and by which his auxiliary tables are formed, will be convinced that he was entitled to prefer this method to all others. It is in the first place, *accurate* to a degree unapproached by any previous method except Bessel's; in the next place the auxiliary tables are extremely simple and concise, and do not require vexatious double interpolations, for the most part, indeed, requiring no interpolations at all; and, lastly, the form of the computation is quite symmetrical and certainly within the grasp of even the most *un*mathematical navigator. Although the method was given to the world in the first volume of our American Ephemeris in 1855, we do not remember having seen it in any of the nautical works of this country or Europe.

We see the old and demonstrably imperfect methods still reappearing in every edition of Bowditch's Navigator, and the English practical works of Raper, &c. Under the head of moon culminations we notice that the author gives an entirely new formula for combining observations according to *weight*, and explodes the old method of regarding the weight of a moon's transit as proportional to the number of threads on which the transit has been observed. He has also incorporated Prof. Peirce's valuable researches on this subject.

The "American Method" of determining longitudes by the electric telegraph, as developed by the Coast Survey is, of course, fully treated, and illustrated by examples.

We are glad to see that the method of finding the longitude by *altitudes* of the moon—discarded by some recent writers—is here restored to its proper place. By the differential comparison of the moon's limb with a neighboring star, as suggested by Prof. Kaiser of Leyden, the method admits of a very great degree of accuracy, and is practical with portable instruments, and especially with the zenith telescope as now constructed for the Coast Survey.

Chapter VIII, on Sumner's Method of finding a ship's position at sea, and Chapter IX, on the Meridian line, and Variation of the Compass, are both brief and need no especial notice.

Chapter X, on Eclipses, is the most considerable chapter of the work. Besides considering all the questions usually discussed, our author goes into a wholly new discussion of the *Occultation of Planets*, in which the elliptical outline of the disc of a spheroidal planet partially illuminated is taken into account. Prof. Chauvenet's methods of solving the various problems relating to the prediction of solar eclipses for the earth, though based upon Bessel's fundamental formulas, are also original, and combine great accuracy with brevity of computation. Since the elaborate paper on eclipses by Mr. Woolhouse in the British Nautical Almanac for 1836, we believe nothing so complete has been produced on this topic; but our author's discussion is not only more complete than that of Mr. Woolhouse, but is both much more elegant in form and more precise. This chapter fills 166 royal octavo pages, and well deserves to be separately published as a complete monograph on Eclipses; for it embraces a discussion of all the phenomena which are included under that name, *i. e.* solar and lunar eclipses, occultations of fixed stars and planets, and transit of the inferior planets over the sun's disc; together with the best methods of applying the observations of these phenomena to the determination of terrestial longitude, or of the solar parallax.

Chapter XI, on the Precession, Notation, Aberration, and annual Parallax of the Fixed Stars, it is sufficient to say, contains

all the matter upon these subjects which belongs to a treatise on Spherical Astronomy, where the physical theory of precession and nutation would be out of place. Chapter XII is equally complete upon the methods of determining the Obliquity of the ecliptic and the absolute Right Ascensions and Declinations of stars by observation.

The first volume concludes with Chapter XIII, on the Determination of Astronomical Constants by observation. This is a brief but clear *resumé* of the methods of determining the constants of the refraction formula, the solar parallax, the mean semidiameters of the planets, the constants of precession, nutation, and aberration, the parallax of a fixed star, and the motion of the sun in space.

Volume II is devoted to the Theory and Use of Astronomical Instruments. Chapter I relates to the Telescope considered apart from any form of mounting, and gives the methods of determining the magnifying power, and a number of practical precepts necessary to the observer.

Chapter II, on the Measurement of Angles, or Arcs, in General, treats chiefly of the errors of graduated circles, of the methods of determining and eliminating eccentricity, periodic and accidental errors, etc., according to the received methods introduced by the German astronomers. The filar micrometer is here also treated, and the methods of determining the value of a revolution of the screw are discussed at length. The investigation of the complete formula for determining the value of a revolution by observations upon a circumpolar star at its greatest elongation, is new.

Chapter III, on Instruments for Measuring Time, embraces clocks, chronometers, and the electro-chronograph, the last being properly regarded as having the same relation to a clock that the micrometer has to the graduated circle. The performance of the various chonographs most in use, is illustrated by full sized specimens of actual work at the Harvard College Observatory and other places.

Chapter IV, on the Sextant and other Reflecting Instruments, contains a full discussion of the theory of these instruments with practical precepts concerning their manipulation. The theory is given in an unusually simple form, and yet appears to be quite complete. The new prismatic instruments of Pistor and Martins, are, of course, not forgotten.

Chapter V, on the Transit Instrument, is, like so many other chapters of this unrivaled work, an exhaustive monograph, and fills upwards of 150 pages. The student who makes himself master of all that this chapter contains on this, the primary and fundamental instrument of the observatory, will be fully prepared to undertake the management of any other instrument.

The author has not only digested into a complete system all the valuable material elsewhere given, but has contributed much original matter. The correction of a transit of the moon or a planet when the defective limb has been observed, which we have looked for in vain in treatises on practical astronomy, is here given in its proper place. The discussion of the probable errors of transit observations is especially valuable. So also are the articles on the use of the portable transit instrument, both in the meridian and in the vertical circle of some circumpolar star. The discussion of an actual series of observations made upon our Northwestern Boundary Survey is full of instruction to the young astronomer. The value of Peirce's Criterion for the rejection of doubtful observations, is here very happily illustrated. Bessel's method of reducing transits over several threads to a single instant, when the instrument is not in the meridian, first given in the *Astronomische Nachrichten*, vol. vi, is here for the time incorporated into a treatise as an essential part of the theory of the instrument. The author has simplified Bessel's method, however, and given a new table which is obviously more convenient than the one given by Bessel for the same purpose.

All the various practicable methods of determining the latitude by the transit instrument in the prime vertical are systematically deduced from a single fundamental formula and their several advantages brought out in a very clear manner, with the aid of full illustrative examples from actual observation.

Finally, the method of determining the declinations of stars with the transit instrument in the prime vertical is given, together with the use of the micrometer in such determinations when the star passes very near to the zenith, a part of the subject usually passed over in silence.

Chapter VI, on the Meridian Circle is likewise complete. The flexure of the telescope is considered. Formulas are given for correcting the observed declination of a planet's limb, both for spheroidal figure and for defective illumination. These formulas are new, it being usual to allow for defective illumination upon the supposition that the planet is spherical.

Chapter VII, on the Altitude and Azimuth Instrument, is also a systematic digest of all that is valuable in this connection. For the reduction of observations over several horizontal threads, the instrument being slowly revolved in azimuth, a method of observation practised at Greenwich with the Altazimuth, we see that the author gives a precise method instead of the rough one used at Greenwich.

Chapter VIII, on the Zenith Telescope, explains in minute detail the method of employing this instrument as practised upon the Coast Survey. We are not sure that Mr. Chauvenet

is quite right in calling the *instrument* "the invention of Capt. Talcott." We have supposed it was rather an improved form of the old zenith telescope, the micrometer taking the place of a graduated arc, although the readings of the graduated arc in the old instrument were differential, as well as in the new instrument with the micrometer. The methods of observation, however, and the processes of reduction, belong to our Coast Survey, and are in this work very satisfactorily explained. The method given for determining the latitude by extra-meridian observations with this instrument is original.

Chapter IX treats of the Equatorial Telescope, adopting Bessel's method of introducing the flexure of the telescope and of the declination axis, and giving the most general formulas, even for the case where the pole of the instrument is quite remote from the celestial pole. The mode of determining the actual position of the instrument is illustrated by observations made with the great equatorial of the Pulkowa Observatory.

Chapter X, on Micrometric Observations, treats first of the filar micrometer in connection with the equatorial telescope. The correction of micrometer observations for the errors of the equatorial instrument is investigated, a subject we do not remember to have seen elsewhere discussed. The complete theory of the Heliometer, according to Bessel, is next given in a concise and simple manner, yet with the same extreme accuracy that we find in all the other parts of the learned author's work. The Ring Micrometer is next discussed. The correction of all kinds of micrometric observations, for refraction, is then investigated after Bessel's method, and the necessary table for facilitating the application is given; and finally there is introduced the method of correcting such observations for precession, nutation, and aberration. The formula for the latter purpose is the same as that of Bessel, but the method of investigation is extremely simple, and, we presume, altogether original.

One of the most important features of the work throughout may be found in the frequent application of the Method of Least Squares to those problems which permit of its employment. This comparatively new, but most powerful and flexible, implement of investigation here receives, for the first time in any extended treatise on the practice of astronomy, its due place, and is introduced in its appropriate relations and bearings, as experienced astronomers are accustomed to make use of it.

The principles of this method are fully discussed in an appendix of about 100 pages, in which its essential features are elegantly and concisely developed, in the clearest form in which it has ever been our fortune to see them in any language. The mystery and complication which have been not unfrequently supposed to shroud and confuse the subject are exorcised by a

master's hand, and not only the deduction of the fundamental and most convenient formulas, but also the distinctions between the various quantities so easily confounded under the general names of "probable error" or "mean error," are made so clear and manifest that the subject cannot appear to the student as either abstruse or confusing.

This appendix is by no means a compilation; it is an original treatise in which previously known formulas are deduced in a new order from the author's own stand-point. Peirce's Criterion for the rejection of doubtful observations is given, together with a very simple criterion proposed by the author, which agrees nearly with that of Peirce.

In conclusion, we would call attention to the intrinsic elegance of the whole treatise, as including a wide field, and not only assigning to each department its own appropriate degree of prominence, but clearly and beautifully presenting them as parts of one whole; thus rendering the work a systematic treatise as distinguished from an aggregate of discussions of different subjects. In the manifest grasp of both the practical and theoretical relations the master's hand is visible. Refined analysis, appreciation of the most convenient application, theoretical accuracy of processes and formulas, practical knowledge of instruments, in short, the requisite, now fulfilled for the first time in a text-book on Practical Astronomy, that the author should be both a mathematician and an observer, all unite to make this new production of Prof. Chauvenet a classic of the highest order, and an invaluable contribution to astronomical science.

ART. XXXIII.—*Remarks upon the causes producing the different characters of vegetation known as Prairies, Flats, and Barrens in Southern Illinois, with special reference to observations made in Perry and Jackson counties;* by HENRY ENGELMANN, Assist. State Geological Survey.

THE district to which I have reference is peculiarly adapted for the study of the causes which produce the differences in vegetable growth, because we find there different systems of vegetation equally well developed in close proximity to each other. We may especially distinguish the prairies, the post-oak flats, the barrens, the post-oak hills, and the corresponding creek-bottoms, and, on a different soil, the white-oak lands.

The prairies in this district invariably occupy the highest ground, but their relative elevation varies considerably. While the lowest edges of some of them reach to within 40, nay, even

20, feet of the level of the principal water courses, the highest prairies are above the heads of swiftly running tributaries of several miles in length. The surface of the prairies is generally flat or gently undulating, and some of them exhibit considerable difference of altitude in their different parts. They are mostly surrounded by timbered flats of more or less extent, and farther on towards the creeks by broken hills. Where there are extensive uplands not level enough to form prairies, but laid out in more or less broken waves, they assume the character of vegetation known in that section as "barrens," while the more broken hills are covered with forest. The differences depend partly upon the configuration of the surface; but other elements must coöperate to produce them: such are unquestionably the quality of the soil, the underlying geological formations, and to a prominent degree the conditions of moisture, as well in regard to the climate or surrounding air, as in regard to the soil and deeper under ground. The geological formations, especially over the more elevated portions of Perry county, consist principally of arenaceous shales and slates and fine-grained sandstones of the upper Coal-measures in nearly horizontal position. The soils and subsoils of the whole district have been formed mainly from their detritus. They are arenaceous, with only a small admixture of clay, and in a high state of comminution, nearly reduced to an impalpable powder. This physical condition produces some properties which we are wont to attribute only to stiff clay. When quite dry the soil rapidly absorbs water; but after having been moist for some time it becomes hardly permeable, the minute particles of the mass soon filling all the pores between the larger grains and closing them hermetically; also whenever water happens to collect in a depression of the surface, the impalpable mud which it carries in suspension soon forms an impenetrable coating on its bottom and prevents the water from sinking. This is analogous on a large scale to what a chemist may daily observe in his laboratory in filtering certain substances. These pools of water remain standing on the ridges, and dry slowly by evaporation. When for some time saturated with water, and especially when mechanically worked in this state either by agricultural implements, or by the tread of cattle, or under the wheels in the roads—when it is puddled as the technical term is —this sandy loam becomes tenacious in consequence of the great adhesive power of its minute particles, and then appears to be far more clayey than it is in reality. Generally it crumbles easily as soon as dry, especially if any mechanical power is applied, and shows again its sandy character. It is not retentive of moisture; in a dry atmosphere it readily gives off the largest portion of the water which it has absorbed, and it reabsorbs the aqueous vapor from the atmosphere with much less power than clay soil does, neither as rapidly, nor in nearly the same quantity.

Occasionally, we also find as substrata a stiff rough clay, and at some points sand.

The prairies all occupy the broad, more or less flat, dividing ridges between the streams. In digging wells on them, water is frequently struck at shallow depths, say, from 6 to 12 feet, and seldom exceeding 30 feet. It is generally obtained in the quaternary surface deposits above the strata of rocks; the latter are seldom reached in the prairies in digging wells, except near their borders, near the flats and barrens.[1] The underlying formations therefore appear not to exercise any direct leading influence in causing the prairie character of the surface, nor does the fine comminution of the soil by itself, because it does not differ in this respect from the adjoining flats and barrens, which is composed of the same sandy loam. I am inclined to the opinion that the leading cause of the prairie vegetation is to be found in the conditions of moisture of the soil, while I concede that various causes must coöperate to prevent the growth of trees, and that in other districts one or the other of these accessory causes may predominate so far as to seem alone to produce this same result.

The prairies in the district under consideration have a very imperfect surface drainage, in consequence of their configuration. The largest portion of the water which falls as rain or snow is therefore taken up by the soil, besides the large quantity which it absorbs directly from the moist air. The first of these sources, the rain and melting snow, would cover the surface to an average depth of 43 inches each year; the quantity of dew cannot well be estimated, but it is quite considerable in some seasons, and the quantity absorbed directly from the moist air, which we are apt to overlook entirely, plays a most important part in the economy of nature, and is large in soils which are rich in humus, like our prairie soils. Prof. Babo has demonstrated that the absorbing power of some dry soils is scarcely surpassed by that of concentrated sulphuric acid, which is used in the chemical laboratories for the special purpose of absorbing the

[1] *Remark.*—In Washington county, which adjoins Perry county to the northward, the same conditions of vegetation prevail, with the only difference that the prairies occupy a still larger proportion of the surface in consequence of the less broken character of the land. There, rocks, mostly soft sandstones, have been struck at numerous points in digging wells in the prairies; but the water is generally obtained either above these rocks, so that only the well beds are excavated in them, or else underneath a few layers merely of these rocks, which then generally reach rather close to the surface, to only from 10 to 20 feet of it. In most of these cases, then, the permanent sheet of water is still near the surface, underneath a rock which is permeable to it, either throughout or locally in consequence of numerous water-bearing crevices. Rock or no rock then makes no essential difference in the drift of our argumentation, which remains unchanged. Points where water is obtained only by considerably deep wells through the rocks come under the exceptions of which I have treated at the end of this article.

[Compare the remarks on the 'Barrens' and 'Sinks' of Kentucky, by B. Silliman, Jr., in an article on Mammoth Cave, this Journal [2], xi, 333, 1850.—Eds.]

humidity of other substances; those rich in humus, clay, or peroxyd of iron, rank highest in this respect. Tile drains in underdrained land of this kind frequently discharge water when the air is moist, but before any rain has fallen. This water has evidently been absorbed from the air by the soil, and this phenomenon proves conclusively the great importance of this absorbing power.

Let us now enquire what becomes of all the water which the prairie soil takes up from the various sources. A portion of it sinks deeper into the substrata and finds an outlet in springs and creeks, but a large portion is retained by the formations nearest the surface, which become saturated with it, so that water can be obtained nearly all year round in shallow wells. Even where the main water level lies deeper, the underclay is generally of such a kind that it allows the water to percolate but slowly. The consequence is, that during that portion of the year when the evaporation is less powerful, in winter and spring, the soil is perfectly soaked with moisture, and the subsoil remains in that state till late in the season. This excess of moisture which must nearly all be exhausted by evaporation naturally affects the growth of plants. It not merely retards their development in the spring by the chilling influence of the evaporation of so much water, but kills and prevents the growth of all those which cannot live with their roots in stagnant water. It also prevents the access to the soil and roots of the oxygen of the air, which is essential to the healthy development of most plants, and without which no oxydation can take place in the soil, especially no decay, no rotting of organic substances, no eremacausis, as Prof. Liebig terms it, which forms an important source of nourishment for the plants. In the absence or under a limited access of oxygen, the organic bodies in the soil putrefy or ferment, whereby much less elements are produced which sustain the life of the plants, but, on the contrary, whereby the roots and the elements of the soil are deoxydized. Acids are thus developed which are injurious to most vegetation; the peroxyd of iron, a highly beneficial ingredient of the soil, is reduced to protoxyd of iron and then dissolved by carbonic and vegetable acids. It then operates destructively upon vegetation, similar to its combination with sulphuric acid, the protosulphate of iron or copperas.

The deeper a plant roots the more obstacles to its growth it finds in the prairies, because it is longer exposed to these baneful influences, which disappear only late in the season, when it is too late for many plants to begin their annual growth. Then the humidity disappears, the soil is opened to the air, and the consequences of the wet spring are overbalanced by the natural richness of the soil. Later in the season these same prairies

which have been excessively wet in the spring suffer considerably from drought, in a great measure certainly because the subsoil is naturally too close, and not opened by deep rooting plants, and therefore does not assist in the absorption of the moisture from the air, nor attract much of it from the water below. Grasses which are not only able to withstand, but even delight in, a considerable degree of moisture, and by their dense growth prevent its early exhaustion by evaporation, and add to it by their attraction of dew, are certainly the plants best adapted to a district like these prairies. By their long continued growth a large amount of vegetable matter has been accumulated in the soil.

I have found the prairie soil in Perry county varying in depth between 10 inches and 2 feet, and underlaid with the white sandy loam with numerous grains of ferruginous matter, from which the upper soil has been gradually formed. Frequently a bed of red or yellow tough clay intervened between the two, and in places formed a regular hardpan which offers much resistance to the passage of water.

The foregoing paragraphs contain my opinion of the principal cause of the absence of trees from the prairies in the examined district. Further investigations may point to other accessory causes which I may have overlooked, but undoubtedly the condition of humidity of the soil exercises here the most prominent influence on its vegetation. The chemical composition of the soil naturally also affects the flora; but as our prairie soils do not appear to have any very peculiar composition, chemistry may account for the absence of certain species of trees, but certainly not for the absence of all trees.

Prof. J. D. Whitney, the distinguished State geologist of California, remarks in his report on the physical geography of Iowa, in vol. i, part 1, of the Geological report of Iowa: "Taking into consideration all the circumstances under which the peculiar vegetation of the prairies occurs, we are disposed to consider the nature of the soil as the prime cause for the absence of forests and the predominence of grasses over this widely extended region; and although chemical composition may not be without influence in bringing about this result, yet we conceive that the *extreme fineness of the particles of which the prairie soil is composed* is probably the principal reason why it is better adapted to the growth of its peculiar vegetation, than to the developement of forests." I have not examined the prairies of Iowa and Minnesota, and therefore confine myself to the suggestion that there too the fineness of the soil may be an accessory cause only, and that the immediate cause may be the conditions of humidity. Several of the proofs which Prof. Whitney adduces may as well, and it seems to me with more right, be claimed as proofs of

my theory. For example, the grass-covered bottoms of former ponds are apt to be still considerably moist, in the spring season at least, much more so than the adjoining forest soil; and the gravelly and timbered ridges of the prairies which he mentions are evidently also better drained in consequence of the coarser material of which they are composed. In the middle and northern part of our state too, while forest trees can be grown on elevated parts of the prairies, and after the same have been dried by continued cultivation or deep tillage and under-draining, they will sicken and die in the lower and moister situations where their roots stand, during part of the year at least, in cold water.

The prairies of our western territories are due to other causes; at least not to an excess of moisure, but rather to a deficiency of it, which, besides depriving the tree of a supply of moisture at the time when it would be required for its growth, also prevents a sufficient decomposition of the substrata, and thus the source remains closed from which the roots of the tree would have to draw their nourishment. I have witnessed a very forcible illustration of this latter defect in the sterile regions of western Utah, where whole mountain ranges are covered with sharp angular fragments of rocks, undecomposed for lack of moisture. Little soil could thus be formed on these slopes, which therefore produce but a scanty vegetation, while there is a most luxuriant growth of delicate flowers at the same altitude on every little rivulet trickling down from the snow-clad summits, and even on the moist patches of soil under and between the melting banks of snow. In other regions, again, the absence of trees and the general barrenness of the country seem to be due to an excessive accumulation of various salts in the upper crust of the soil, such as sulphate of magnesia, chlorid of sodium, carbonate of soda, and others, but which accumulate also in consequence of the insufficient drainage, due to the small amount of atmospheric precipitation.

In the district which claims our special attention, the prairie growth is undergoing a considerable spontaneons change with the progressing settlement and cultivation of the country. Since the prairie grass is no longer burnt off annually, as it used to be by the Indians and early settlers for purposes of the hunt, for killing insects and snakes, and in order to free the land from dry stalks, and thus to secure a better pasturage early in the spring, whereby all but the hardiest grasses were destroyed, and those especially remained which propagate by throwing out suckers from the roots, and since the grass is continually cropped close and tramped down by cattle, the former vegetation of the prairies has gradually given way to softer and shorter grasses, and at somewhat broken points even shrubs and trees

have began to sprout up; at the same time their surface has become drier, of which more will be said below.

At some points in the prairies no water is obtained at moderate depths, but rocks are struck and have to be penetrated to a considerable depth in order to get water. At such points we might expect to find trees, but such is usually not the case. In the vegetable kingdom also the universal rule prevails that the stronger gain on the weaker ones. The tenacious grasses growing all around such spots will then encroach upon the land which is fit to bear timber, and will not suffer trees to spring up, unless they be assisted by favorable circumstances. Such encroachment of one species upon the territory else occupied by another, even to the extinction of the latter, may be frequently observed.

The "flats" are nearly level stretches of upland, as their name indicates, and are timbered principally with single large and widely scattered post oak (*Quercus obtusiloba*), of a sturdy thickset growth, with stout crooked branches, and a tattered top. Their trunks are generally in part rotten, perhaps in consequence of injuries which they received by fire during the earlier period of their growth, more likely, however, it appears to me, in consequence of the, at times, quite unfavorable condition of the ground upon which they grow, which may produce disease in the tree. The trees of the large post oak stand wide apart, and are interspersed with black jack (*Quercus nigra*) and in places young post oak. The black jack are sometimes well developed with a vigorous growth and well shaped top, but are frequently stunted and scrubby. Not being, here at least, a long-lived tree, they generally do not attain a large size. These woods are quite open, and their white soil is only scantily covered with vegetation. Even where the annual fires are kept out, undergrowth is very slow in springing up in the regular flats. Their subsoil is the finely comminuted white sandy loam mentioned above; it is nearly pure white, with an admixture of small black grains of ferruginous matter, and reaches to a depth of several feet. The upper soil is quite shallow, and seems to be distinguished from the subsoil only by a slight admixture of vegetable mould, not sufficient to color it much darker, and by the smaller number of the ferruginous grains. For the iron gradually disappears from most badly drained surface soils, and sinks deeper into the subsoil, in consequence of repeated reductions of the peroxyd into protoxyd, its solution, and final reoxydation and precipitation. A sharp line cannot be drawn between the upper soil and subsoil of the post-oak flats. They exhibit the peculiar properties which I have above described as characteristic of this kind of soil, which are not obliterated by the small admixture of humus. Its fine comminution makes this otherwise light soil

badly permeable to water; and in depressions where rain water collects, the fine particles which have been held in suspension by the accumulating water soon close up the pores of the bottom, and thus shallow pools are formed, from which the water disappears slowly by evaporation. At such points we observe the pin oak (*Quercus palustris*) together with the scaly-bark hickory (*Carya alba*), and sometimes the laurel oak (*Quercus imbricaria*).

The flats extend either round the prairies, between them and the breaks or hill land, and at the same level with the edge of the prairies, or else they occupy the wider ridges without a central prairie. The most obvious difference between prairies and flats, apart from their different vegetation, consists in the different quality of their soils, which in the prairies is deeper and much more charged with vegetable matter; but as the soil is only formed in the course of time, we must search for a deeper seated first cause of the difference. The situation of the flats between the imperfectly drained prairies and the broken hill land gives us a clue. The flats are equally deficient in surface drainage with the prairies, but the permanent water-line appears to lie considerably deeper, and the lower substrata effect a natural drainage wanting to the prairies. I have scarcely any data in regard to the depth at which water is generally struck in the flats, because they have hitherto been shunned by settlers on account of their apparent unproductiveness, which disappears however before a rational system of cultivation. In most cases where wells have been dug near the boundaries of prairies and flats, water has been found considerably deeper than farther in the prairies, and many attempts at wells have been abandoned before it was reached; at the outer rim of the flats we approach, besides, the natural water courses; and we have therefore good reason to suppose that generally the substrata of the flats are drained by the underlying sandstone formation. Early in the spring the surface of the flat is exceedingly wet, on account of the deficiency of the surface drainage and the limited permeability of the soil and subsoil, which are then saturated with water to their fullest capacity. This water will mostly be consumed slowly by evaporation, and that small portion of it which penetrates deeper will be drained off. Vegetation will thus be retarded in spring, and all the bad influences will be experienced of which I have spoken in relation to the prairies. At last the soil remains closely packed and dry. The access of air to it is then still limited in consequence thereof, and when the hot season arrives the soil can absorb only a small amount of moisture from the air, in consequence of its compactness and of its deficiency in clay and humus, which two elements are known to absorb most powerfully the moisture and other gaseous elements of the air which are conducive to a vigorous development of vegeta-

tion. The same cause prevents the parched surface from drawing upon the substrata for a supply of humidity from the deep seated permanent water-level; and moreover it is generally assumed that, whenever the depth of the water-level exceeds a few feet, it can exercise a comparatively small influence upon the humidity of the soil in the dry season, during which the main supply of water for the vegetation seems to be absorbed by the leaves and by the soil directly from the atmosphere. The excessive humidity of spring is therefore followed on the flats by an excessive drought, almost without a congenial growing season between. The closely packed condition of the soil presents also an obstacle to the deep-penetrating roots, and the latter are not invited to any exertion in that direction, because the same cause prevents the access of oxygen and of other elements of nutrition. A heavy rain which would be absorbed in a short time by a coarser light soil or by well drained land, and which would only be sufficient to saturate heavy soils, and to supply them with all the water they need for some time after, will be apt to pack the surface of the flats and to flood them without penetrating deep; it will soon be dried by sun and wind, and will suddenly chill the soil, without exerting to a large degree the beneficial influences which it would have on a more favored soil.

While the former vegetation of the prairies seems to have been one suited to wet ground, the flats in their unimproved state will only sustain one which is able to outlive the excessive wet of the spring season, and the sudden change to the dryness of summer and fall. The trees which grow there are such as have shallow spreading roots, and can withstand considerable drought; deeper rooted ones would be killed in the spring, and more delicate plants would wither under the scorching sun of summer and fall if they did survive the spring. Other causes which determine the vegetation of the flats may be found principally in the chemical properties of the soil.

Such is the condition of the typical flats in their uncultivated state, where they present their worst features; there are however gradations to the better, and they are by no means as unproductive as it might appear. They were so, indeed, under the old system of pioneer cultivation, which expected nature to do everything, and man as little as possible; but if the soil is opened by deep cultivation, and vegetable mould is created, and the soil loosened by ploughing under green crops and manuring, it will be found to improve steadily as soon as the roots have once began to penetrate it. The first crop is frequently quite defective, but each succeeding one is better. In this respect the soil resembles stiff clay soil, such as potters clay, which, with all chemical elements of fertility, generally makes a quite barren soil until it is sufficiently opened by cultivation.

The "*barrens*," as the term is understood in the district to which I have reference, are hills covered with a dense growth of tall grasses, without or with only scattering large trees. The progressing cultivation has however changed their aspect considerably, and large portions of them now have a dense growth of young timber. They occupy that portion of the upland the surface of which is too uneven for prairies and flats, partly gently undulating, partly sharply rolling or even moderately broken. Their subsoil is the same white sandy loam mentioned before; but their surface-configuration affords a complete drainage, and they have therefore sustained a better vegetation and have formed some inches of a good soil considerably charged with humus. That of the sharper ridges is however apt to wash down into the the hollows, and is therefore generally shallow, while it has accumulated in the lower places. Their subsoil is frequently, but erroneously, called yellow clay; it is yellow only on exposed surfaces, on cuts in the roads, and similar places, where the iron of the soil, which elsewhere is all concentrated in small grains of dark brown color, is more diffused over the surface and colors the white material yellowish. The drainage of the substrata seems also to be perfect, and the underlying porous sandstones not unfrequently reach to within a few feet of the surface. The barrens become dry early in the spring, and resist drought better than the flats, apparently because their upper soil is better and attracts more moisture from the air, and because it is less packed than that of the flats, and the plants, in consequence of their earlier growth, have progressed farther in their development when the dry weather sets in, and are more vigorous. The subsoil is also very close. Still there seems to have been no absolute necessity for the absence of timber, and it rather appears to have been due to the encroachment of the grasses, which, being well developed in the large prairies, where no timber could grow, spread out and took possession of the barrens. Other lands very similar to the barrens, in regard to soil and situation, are timbered with post-oak forest. The annual fires which swept over the country assisted in keeping down timber, and in giving the grass entire possession; and perhaps the latter was necessary to prepare the soil for the subsequent growth of timber. In some thinly settled neighborhoods we still find the barrens covered with rank coarse grass, but generally a dense growth of small oak is springing up spontaneously, and at many places very vigorously, especially in the more inhabited districts. At some points we find in the barrens single large post oak, as we do on the flats; generally the young growth on the poorer ridges is post oak (*Q. obtusiloba*) and black oak (*Q. tinctoria*) with some blackjack (*Q. nigra*), in the hollows hazel and sumach, and on the finer rolling lands post oak, black

oak, barren hickory (*Cayar tomentosa*), hazel, &c. The growth varies considerably according to local circumstances.

The "*post-oak hills*" resemble in most respects the barrens, but are covered with older forest, and are on the average more broken. The prevailing timber is post oak, with some black oak, but we find also blackjack, hickory and some other trees. White oak (*Q. alba*) is found only in the breaks of the creeks. The main difference between this forest and the barrens seems to consist in the more progressed growth of timber, due probably to the more complete drainage of the soil, aided by a more profuse admixture of sand and other materials in the subsoil from the strata which form the hills. In wet spots we find here also some pin oak (water oak, *Q. palustris*) and laurel oak (*Q. imbricaria*).

The *principal creek bottoms* within the region of the barren country and of the sandstones of the upper Coal-measures have a soil very similar to that of the flats, perhaps a little coarser; but its upper portion is considerably mixed with vegetable mould, and about as dark as the prairie soil. They are overflowed by freshets, and very naturally supplied with the necessary moisture from the creeks, even in the driest season, and their growth is thereby regulated. The timber is heavy and very tall, and consists principally of the swamp white oak (*Quercus bicolor*) and the pin oak (*Q. palustris*) with some scaly-bark hickory (*Carya alba*); but where the creeks enter the limits of the underlying limestones and shales the growth is much more varied, and consists, in addition to the above named trees, of bur oak (*Q. macrocarpa*), red oak (*Q. rubra*), laurel oak (*Q. imbricaria*), ash, black walnut, hazel, and many others.

The *white oak* is found in this district only in the steep breaks of the creeks and at a few other points, but it is altogether subordinate. At the southern limit of this region the soil changes entirely, and covering "*the ridges of the Millstone grit formation,*" we find a light brownish, decidedly arenaceous, deep, light, and warm soil which supports a splendid growth of white oak, black oak, barren hickory, pig nut (*Carya glabra*), black walnut, black gum (*Nyssa multiflora*), yellow poplar (*Liriodendron tulipifera*), &c. The prairies do not extend into this district, and the Sylva here, beginning in Jackson county, and especially farther south, undergoes a considerable change, which is partly caused by a change in the geological formations and surface configuration, and consequently of the soil, partly by the southern slope and latitude of this part of the country. Of trees which do not extend farther north into the before-described Coal-measure district, I observed here the yellow poplar (*Liriodendron tulipifera*), the swamp cypress (*Taxodium distichum*), the tupelo-gum (*Nyssa uniflora*), the sweet gum (*Liquidambar styraciflua*),

the winged elm (*Ulmus alata*), the Spanish oak (*Quercus falcata*), the barren oak (bitter oak, *Q. falcata* var. *triloba* (?)), the beech (*Fagus ferruginea*), the cucumber tree (*Magnolia acuminata*), and others.

Progressing change of the country.—From the foregoing statements it appears that timber is now encroaching spontaneously upon land formerly occupied by tall grasses, while, on the contrary, old forests yield to the axe and ploughshare; at the same time, the rank prairie and barren grasses die out. The effect upon the climate, especially in decreasing the humidity of the country, must be powerful, and may be compared to the change of sensation which we experience, on a clear summer evening, in coming from a sheltered damp creek bottom to the airy top of a dry hill. The effect is similar to that produced in other countries by the clearing of extensive forests. The growth of dense tall grasses, of which untold generations have died and rotted upon the same spot, not only protects the soil from the warming rays of the sun and thus checks evaporation, but it actually increases the precipitation of moisture, especially in the form of dew, by the low degree of temperature consequent upon the humidity of the surface and upon the powerful radiation of heat from the spears and leaves of the grass waving in the night air, which, as can easily be proved by experiment, grow much colder than the bare soil. The grasses also check the surface drainage most effectually. With their disappearance the above effects cease, the soil becomes more exposed to the direct rays of the sun and to the drying breezes, while the succeeding growth does not favor the precipitation of dew nearly as much as the grass. The natural impediments to the speedy abduction of the falling rains are also lessened to a considerable degree, and thus the soil is rendered drier. The artificial works of drainage and even the cuts and ruts of the roads do their share also. The breaking up of the sward and deep cultivation of the soil facilitate the sinking of the water, and expose a greater surface of soil to the desiccating influence of the sun and winds. Every old settler can bear witness to the remarkable and rapid change in the conditions of moisture of the prairies, which is also manifested by the gradual failing of the wells at numerous points. It is a common observation that they must be dug much deeper now than formerly in the same vicinity. The healthiness of the country has thereby improved, and the farmer is enabled to plant much earlier, and at points which were formerly too wet; his loss by the freezing out of the winter crops is much reduced. The droughts in summer and fall are perhaps also more severe at present, but an advantage can seldom be gained without some sacrifice, and a remedy is accessible if only we will apply it.

It is "thorough cultivation and underdraining." Where these are practiced, the roots are enabled to strike deeper, beyond the direct influence of the sun's rays; a much larger quantity of nourishment is presented to them; the humidity of the soil is equalized; its absorbing power for moisture and gases is vastly increased; and the growth of the plants is consequently much invigorated and placed beyond the reach of sudden changes of the weather. If the farmer, instead of superficially cultivating extensive tracts of land with an altogether inadequate laboring force, as I have frequently noticed, would thoroughly cultivate a smaller area, he would not have to complain so much of drought and failure of crops, and of the "giving out" of fields. Instead of exhausting his soil, he would make it richer every year; and, by making heavy and certain crops, he would find himself amply repaid for the increased labor, and reap more on an average on the smaller surface adequate to his laboring force, than before on the larger fields.

Springfield, Ill., August, 1863.

ART. XXXIV.—*On the Earth's Climate in Paleozoic Times;* by T. STERRY HUNT, M.A., F.R.S.[1]

THE late researches of Tyndall on the relation of gases and vapors to radiant heat are important in their bearing upon the temperature of the earth's surface in former geological periods. He has shown that heat, from whatever source, passes through hydrogen, oxygen and nitrogen gases, or through dry air, with nearly the same facility as through a vacuum. These gases are thus to radiant heat what rock salt is among solids. Glass and some other solid substances, which are readily permeable to light and to solar heat, offer, as is well known, great obstacles to the passage of radiant heat from non-luminous bodies; and Tyndall has recently shown that many colorless vapors and gases have a similar effect, intercepting the heat from such sources, by which they become warmed, and in their turn radiate heat. Thus while for a vacuum the absorption of heat from a body at 212° F. is represented by 0, and that for dry air is 1, the absorption by an atmosphere of carbonic acid gas equals 90, by marsh gas 403, by olefiant gas 970, and by ammonia 1195. The diffusion of olefiant gas of one inch tension in a vacuum produces an absorption of 90, and the same amount of carbonic acid gas, an absorption of 5·6. The small quantities of ozone present in electrolytic oxygen were found to raise its absorptive power from 1 to 85, and even to 136; and the watery vapor present in the air at ordinary temperatures in like manner produces an absorption of heat

[1] Communicated to this Journal by the author.

represented by 70 or 80. Air saturated with moisture at the ordinary temperature absorbs more than five hundredths of the heat radiated from a metallic vessel filled with boiling water, and Tyndall calculates that, of the heat radiated from the earth's surface warmed by the sun's rays, one-tenth is intercepted by the aqueous vapor within ten feet of the surface. Hence the powerful influence of moist air upon the climate of the globe. Like a covering of glass, it allows the sun's rays to reach the earth, but prevents to a great extent the loss by radiation of the heat thus communicated.

When however the supply of heat from the sun is interrupted during long nights, the radiation which goes on into space causes the precipitation of a great part of the watery vapor from the air, and the earth, thus deprived of this protecting shield, becomes more and more rapidly cooled. If now we could suppose the atmosphere to be mingled with some permanent gas, which should possess an absorptive power like that of the vapor of water, this cooling process would be in a great measure arrested, and an effect would be produced similar to that of a screen of glass; which keeps up the temperature beneath it, directly, by preventing the escape of radiant heat, and indirectly by hindering the condensation of the aqueous vapor in the air confined beneath.

Now we have only to bear in mind that there are the best of reasons for believing that during the earlier geological periods all of the carbon since deposited in the forms of limestone and of mineral coal existed in the atmosphere in the state of carbonic acid, and we see at once an agency which must have aided greatly to produce the elevated temperature that prevailed at the earth's surface in former geological periods. Without doubt, the great extent of sea, and the absence or rarity of high mountains, contributed much to the mild climate of the Carboniferous age, for example, when a vegetation as luxuriant as that now found in the tropics flourished within the frigid zones; but to these causes must be added the influence of the whole of the carbon which was afterwards condensed in the forms of coal and carbonate of lime, and which then existed in the condition of a transparent and permanent gas, mingled with the atmosphere, surrounding the earth, and protecting it like a dome of glass. To this effect of carbonic acid it is possible that other gases may have contributed. The ozone, which is mingled with the oxygen set free from growing plants, and the marsh gas, which is now evolved from decomposing vegetation under conditions similar to those then presented by the coal-fields, may, by their great absorptive power, have very well aided to maintain at the earth's surface that high temperature the cause of which has been one of the enigmas of geology.

Montreal, August 1st, 1863.

Note to paper on the Earth's Climate in Paleozoic Times.—Since the above was in type, my attention has been called by Prof. Dana to a paper published in 1849 by the late Major E. B. Hunt, U. S. Engineers, on Terrestrial Thermotics. In this paper, which appears in the *Proceedings of the American Association* for that year, page 153, and is referred to by Dana in his *Manual of Geology*, page 363, Major Hunt argues that the temperature at the earth's surface increases with the barometric column; and that, as the atmospheric mass must have been greater in the earlier geological periods, by the amount of carbon and carbonic acid since abstracted from it, the temperature must have been higher. To this effect of the carbonic acid, is to be added, as Mr. Dana has remarked, the greater moisture of the insular climate of the Carboniferous period, when the excess of aqueous vapor would have contributed to increase the weight of the atmospheric mass.

The slight augmentation of the barometric column dependant upon these additions to the atmosphere would however probably be inadequate to produce the considerable difference in climate which it is proposed to explain, and it is only in the light of Tyndall's recent discovery of the great absorptive action exerted by certain gases and vapors on radiant heat, that the chemical constitution of the atmosphere of that time enables us to solve the problem of the warm climate of the Paleozoic period, towards which, however, Major Hunt made as great a step as the existing state of science permitted, when in 1849 he attributed it to atmospheric conditions.

ART. XXXV.—*Correspondence of Jerome Nicklès, dated July 5th*, 1863.

Obituary.—Of scientific men, deceased in France since my last correspondence, the following are leading names:—the physicists Despretz and Bravais, the botanist Moquin-tandon, the geologist Marcel de Serres, the chemist Péan de St. Gilles. A few details may be here appropriate touching each of these savants, some of whom, as Bravais and Péan de St. Gilles, have died in the prime of life and maturity of talent, without having been able to produce all that we could have expected from their attainments and zeal.

César Mansuète Despretz died at six in the morning, March 15th, 1863. Born in Lessines, (Hainault), on the 13th of March, 1789, of poor parents, he was, to use an expression peculiar to France—the *son of his works*. Active, studious, very intelligent, and eager for instruction, he came to Paris, attended there the course of physics and chemistry, and speedily brought himself to the notice of Gay-Lussac, who took especial note of the patience and perseverance of his young scholar, and chose him as assistant professor in his course of chemistry at the Polytechnic school.

In 1824 he became professor of physics, in the college of Henry IV, where he had for some time acted as tutor, and in 1837 was appointed to the same chair in the Faculty of Science in Paris, in the place of Dulong. In 1841 he was appointed to fill the vacancy in the Institute caused by the death of the illustrious physicist Savart, and in 1858 was called to the presidency of the Academy.

His first publications date from 1818, when he began with important researches upon the latent heat of vapors. In 1819, he was occupied with the elastic force of vapors. At that time, physicists agreed with Watt that *the total amount of heat contained in a given weight of saturated vapor of water is constant at all pressures and at all temperatures.* Despretz, on the contrary, concluded from his own experiments, that *the latent heat increases with the pressure and the temperature, but to a less amount than the increase of the temperature.* His results are now universally adopted.

The researches which he published in 1822 on *the causes of animal heat*, were "crowned" by the Academy, which had proposed this subject for investigation:—"Compare the heat developed by a warm-blooded animal, in a given time, with the heat developed by the CO^2 and HO formed in the respiration of the same animal during the same time." On this occasion Despretz gave his attention to a series of researches upon the composition of the air and the respiration of reptiles; perceiving that, besides the carbonic acid formed in the respiration of these animals, there was also some nitrogen.

He also discovered that fishes have a higher temperature than that of the water in which they live;—that new-born infants have a temperature about two degrees higher than that of man, and that the same is true with animals, etc.

His researches upon the conductibilities of bodies were also productive of results which have been accepted by science, and which are almost entirely confirmed by corresponding results obtained by Mr. Forbes of Edinburgh. In this line of research, Despretz was preceded only by Ingenhousz.

In his researches upon the compressibility of liquids, he was the first to perceive that this compressibility was in a decreasing ratio (1823).

In 1825, he was occupied with the study of the heat developed in the combustion of carbon, hydrogen, phosphorus, and many of the metals, in the investigation of which, he, for the first time, burned metals in a calorimeter. Out of many interesting facts resulting from these researches, we note this one:—tin and the protoxyd of tin emitted the same quantity of heat for the same volume of oxygen absorbed.

While studying the density of gases at different pressures, in 1827, he discovered that all gases follow Mariotte's law, while they are strongly compressed, and that they possess variable compressibilities.

In 1828, he studied combustion under different pressures; in 1829, the modifications which metals suffer, under the combined action of heat and ammoniacal gas, discovering the fact that iron will combine directly with nitrogen, forming a nitrid. But only recently, and as one result of the great labors of St. Claire Deville and Wöhler, has it become certainly known that nitrogen has a very strong affinity for many of the metals, and is fitted to combine with them.

But space would fail us to speak particularly of all the works published by Mr. Despretz, even in the last years of his life. We have before[1] spoken of some of these, especially of his researches upon the nature of simple bodies (1859), which occasioned a discussion on the part of Mr. Dumas, so interesting and at the same time so profitable to science. We have also spoken of that interesting memoir in which, under the modest title, "Observations upon charcoal," he shows the possibility of making artificial diamonds.

The works remaining for especial mention are those "upon the variations of the zero in the thermometer in the same course of experiments;" "upon the luminous power of the pile, with reference to the number and disposition of the elements;" "upon the limit of the chemical power of the pile;" "upon the chemical work of the pile;" "upon the law of currents;" "upon the tangents-compass;" "upon the constancy of the pile;" etc.

But let us look at the principal results of these researches,—results which have taken their place in science, and which it is well to call to mind, now that the grave has forever closed over the humble and venerable savant who was their author.

Mr. Despretz has furnished experimental demonstration,—1st of the decrease of the compressibilites of liquids with the pressure; 2d, of the unequal compressibilities of gases; 3d, of the increase of the compressibilities of gases with the pressure; 4th, of the law of the propagation of heat in liquids; 5th, of the generality of the law of the propagation of heat for all bodies, whether good or bad conductors; 6th, of maximum density as a property appertaining to all aqueous solutions, and of the existence of this maximum at a temperature lower than that of congelation, for a great number of solutions; 7th, of the constancy of the quantity of heat disengaged, whatever the pressure may be, in the phenomena of combustion, where the volume of oxygen is not changed; 8th, of the fusibility and volatility of all bodies, even of carbon; 9th, of the non-influence either of the tension or quantity upon the rays of the voltaic spectrum; 10th, of the influence of the position of the poles, in the vertical voltaic arch, upon the length of this arch; 11th, lastly, of the artificial production of microscopic diamonds by the electric current, whether wet or dry.

Such are some of the discoveries which belong solely to this zealous experimenter.

Despretz did not believe in grand theories, and never founded a school. His genius consisted in patience for every investigation. By persevering labor and a strong will, he attained to that superiority which others owe to natural talent.

His manner of life was very austere; he always wore clothes of sombre hue, which caused him to be often mistaken for a priest, and which he did not change even when preparing for the chase, of which he was passionately fond. He was not married, and took his meals every day at the same hour, at a restaurant which owes to him its popularity among chemists and physicists of all parts of the world; for it was a great pleasure to him to invite to his modest repast such men of science as might arrive from abroad. From this circumstance I take the liberty

[1] This Journal, [2], xxviii, 121.

of giving some details of these repasts, now become classic, and which Mr. Despretz did not renounce until, having lost his entire fortune in 1847 in a railroad enterprise, he believed he ought to impose upon himself very severe privations. The repast in question was composed almost invariably of *soup á la Julienne; oysters; Normandy sole;* in summer, *beefsteak*, in autumn and winter, a *roast* from the results of his hunting; lastly, *fruits* and *coffee*. When he had no guests, he took for his morning meal a cup of milk, while receiving calls.

He left numerous manuscript notes, and a library well supplied with French, English and German works.

Marcel de Serres died at Montpellier, July 22d, 1862, at the age of 82, in the midst of scientific labors, and almost, as it were, without laying down his work. * * *

[A notice of the life and labors of de Serres will be found in vol. xxxiv, p. 303 of this Journal.—Eds.]

Horace Benedict Alfred Moquin-tandon was born at Montpellier, May 7th, 1804, and died on the 15th of last April. Called to the Faculty of Sciences of Toulouse in 1833, as professor of botany, in 1850, together with Mr. Montagne, he was appointed by the government to make a thorough examination of the flora of the island of Corsica. After the death of the botanist Richard, in 1853, Moquin-tandon was appointed to fill his place as professor of botany to the Faculty of Medicine of Paris, and director of the botanic garden belonging to that institution. The following year he was elected an acting member of the Academy, having previously been a correspondent. He was vice-president of the Society of Acclimation.

He published various researches upon both zoology and botany; among them, the following:—"Upon the manner in which the officinal leeches first enter the skin, and on the wound which they inflict;" "Monograph of the family of the Hirudines," 1 vol. 8vo, with another of 44 plates—"Researches upon the Ancylus," "Essay upon the duplication of organs of vegetables"—"Elements of vegetable teratology," (1841), &c.

As a professor, Moquin-tandon was endowed with a happy ease of manner, and united to the clearness of verbal demonstration a great facility of representing upon the board, in a simple and rapid manner, the form and structure of the object which he was describing.

Auguste Bravais was born in 1811, at Anonnay (Ardèche). While serving in the capacity of midshipman, he made a voyage to the Polar regions, in 1836, and, upon his return, published a report upon numerous meteorological and geological observations. Having attained the rank of lieutenant, he left the service and accepted a professorship in the Faculty of Sciences at Lyons. In 1846 he was appointed to the chair of Physics at the Polytechnic school, and in 1854 was elected to the Academy, to fill the place made vacant by the death of Admiral Roussin.

Among his published works, we may mention the following:—"Essay upon the general disposition of rectiseriate leaves"—"Memoir upon the old coast-lines of the sea of Finmark"—"Upon the crepuscular phenomena"—"Upon symmetrical polyhedrons"—"Studies upon crystallography"—"Upon parhelia"—"Upon the white rainbow"—"Upon halos"—"Influence which the rotation of the earth exercises upon the movement of the conical pendulum"—"Researches upon feeble double refractions."

Having suffered many years from a disease of the brain, he was at length compelled to give up all scientific labors: in his last years he was reduced to childishness. He died in March last.

Léon Péan de St. Gilles was born at Paris, January 4th, 1832, and died March 22d, 1863, at the age of 31.

Though always in delicate health, he chose a career little compatible with his constitution, viz: that of a chemist. Possessing a large fortune, he fitted up a fine laboratory, where he delighted in passing his whole time, by this close confinement, doubtless, hastening his death.

The following are a few of his works deserving mention:—"Upon many new sulphites of the bases Hg^2O and Cu^2O"—"Upon the hydrate and acetate of iron." These two memoirs have been the subjects of very favorable reports from Messrs. Balard and Thénard.—"Various experiments relating to the comparative action of nitric acid and mercury upon sulphur in its insoluble and its crystalline states"—"Upon the oxydizing properties of permanganate of potash;" lastly, "Researches upon affinities," undertaken in concert with Mr. Berthelot, which his death suddenly broke off.

Discovery of fossil man.—We have before mentioned[2] (1860) facts relating to this subject, in reviewing the long continued efforts of Mr. Boucher de Perthes to establish the fact that man was cotemporaneous with the larger animals whose remains we find fossilized. Perthes founded his opinion upon the presence, in the Post-tertiary deposits, of wrought articles, and, in general, of the products of human industry, associated with bones of *Ursus spelæus*, *Elephas primigenius*, &c. These articles consist mostly of flint wrought to the form of hatchets or daggers, together with bones bearing evident signs of having been worked. One thing remained to be accomplished—the discovery of man himself in a fossil state; for one could reasonably say, that, if man were cotemporaneous with the *Ursus spelæus*, we ought to find his fossil remains in connection with those of the larger animals.

This discovery was made at the commencement of the present year, by Mr. de Perthes, upon the same formation with his previous discoveries in an open gravel pit, called Moulin Quignon.

We will not here repeat all the particulars of the authentication of this discovery which was immediately carried out by Messrs. de Quatrefages and Prestwich. English paleontologists having expressed doubts (*London Times*, April 25th, 1863), a sort of international congress was decided on to settle the question. Under the presidency of Milne-Edwards, uniting great learning and a conciliatory spirit, and after many sessions at the Museum, they adjourned to Abbeville, where, after taking great care to prevent any deception, they made new excavations, and, at the depth of four metres, in a bed apparently identical with that from which the jaw had been extracted, found many hatchets of flint every way similar to those previously examined whose authenticity had been doubted by the English savants. The details of this remarkable congress can be found in the interesting report which Milne-Edwards presented to the Academy, at the sitting of May 18th.

[2] This Journal, [2] xxix, 269.

Finally, the question takes a new phase, for Elie de Beaumont does not admit that the deposit at Moulin Quignon belongs to the Post-tertiary, but classes it with "deposits laid down upon hill-sides," and considers it, consequently as more recent than the diluvium.

Milne-Edwards, without wishing to discuss with E. de Beaumont, the stratigraphical question, which is not in his province, persists in considering it very probable that the jaw from Moulin Quignon is cotemporaneous with the fossil bones obtained from the same quarry. Both geologists and paleontologists, in general, share the opinion of the illustrious geologist, but the point is still in discussion. [For a notice of this discovery, see this vol. p. 123.—Eds.]

The manufacture of alcohol by means of illuminating gas.—The industrial world has been, for some time, much interested in a process for the production of alcohol by means of illuminating gas, at a very low cost (25 francs per hectolitre), and one litre of alcohol so prepared is mentioned among the principal curiosities at the London Exhibition. Moreover, it has been said by some journals, both in France and elsewhere, that the manufacture is going on at St. Quentin, and that the apparatus which receives coal upon one side pours out alcohol on the other.

These are exaggerations of certain results obtained by a company which has been organized at St. Quentin for undertaking the application of a patent obtained by Mr. Cotelle, a manufacturing chemist. The patent is founded upon the experiment by means of which Berthelot, in 1855[3] accomplished the synthesis of alcohol, by causing the absorption of olefiant gas, C^4H^4, by sulphuric acid, thus converting it into sulpho-vinic acid, a compound readily turned into alcohol by processes long since known.

This experiment, made known by Hennell, thirty years ago, has now been repeated with C^4H^4 prepared from alcohol. Mr. Cotelle employs mostly illuminating gas, which, as we know, contains from 4 to 12 per cent of C^4H^4. Separating this by means of sulphuric acid, there remains a gaseous mixture, composed of C^2H^4, CO, H, &c., very suitable for burning, so that this first material ought to cost very little, especially if the manufacture be undertaken at the mines, so as to take advantage of the gas which issues from the coke furnaces.

To produce one hectolitre of alcohol of 90 per cent, Mr. Cotelle uses not more than 40 cubic metres of C^4H^4, which corresponds to about two tons of the northern coal used at St. Quentin.

But the difficulty is not solely in the production of C^4H^4; there is also needed a large amount of concentrated sulphuric acid, (10 parts of $HOSO^3$ to 1 of alcohol). This, used at 66° of Beaumé's areometer, remains, after the completion of the work, at from 20° to 25°. It is necessary, then, either to concentrate it again for a new process, or to utilize it in its diluted state; from this we see the necessity for either concentrating apparatus or leaden chambers; for a hectolitre of alcohol requires for its production 1500 kilometres of sulphuric acid at 66°.

Thus we perceive a series of difficulties which are not yet overcome, but which are vanishing, day by day. Still, Cotelle's process is interest-

[3] This Journal, [2], xx, 111, 264.

ing and we will give it in a few words. Starting with the purification of gas, we free it from sulphydric acid and ammonia, then desiccate it by passing it over $HOSO^3$. Drawn along by suction like that of a pump, the dry gas is directed to a column of glass or sandstone furnished with trays or diaphragms pierced with small holes, from which descends $HOSO^3$ in a finely divided state to meet and dissolve the C^4H^4. This solution takes place slowly, so that the apparatus needs as many as forty trays to distribute enough sulphuric acid to absorb the gas and be saturated with it.

The sulpho-vinic acid thus obtained is next treated with five times its volume of water, and the mixture submitted to the action of a stream of vapor which carries over the alcoholic product. The vapors are condensed; the alcoholic liquid thus obtained is re-distilled over a little lime, to separate any sulphuric acid which may have distilled over, and the liquid condensed from this distillation is rectified to produce alcohol of 90°.

The residue of this operation is, as we have seen, sulphuric acid of 20° to 25°, and a gaseous mixture representing the gas from ordinary coal less HS, NH^3, and C^4H^4: this latter can be advantageously used for fuel.

New method for the concentration of mineral waters.—Sea-water in freezing, forms flakes of ice consisting of nearly pure water, and an extremely saline liquid which in Northern countries is utilized in the production of marine salt. Very recently, Dr. Robinet, a physician of Paris, has discovered that the same process can be applied in the purification of fresh water. In freezing water from the Seine, from wells, and from springs, he found the ice produced to be so entirely free from the salts of lime and magnesia which were contained in the water, that, thus purified, it may be considered as nearly equal to distilled water. So it is now proposed to procure water on board ships, no longer by distillation but by congelation, by means of the apparatus of Mr. Carré, of which mention is made below.

The same fact is made use of in the concentration of mineral waters, a problem which has offered itself for a long time, but which the employment of heat could not solve, on account of the gas originally in solution, which the heat expelled. Cold works better. Dr. Ossian Henry, of Paris, has experimented with forty different varieties of water, and finds that it is possible by congelation, to reduce mineral waters to one-eighth, one-tenth, one-fifteenth, or even one-twentieth of their original volume, without producing any alteration in the gases contained in them.

100 litres of mineral water can thus be reduced to 5, giving great economy in transportation; moreover, the ice itself is also valuable. But we do not believe that the therapeutic properties of the extract will be identical with those of the water in its original state, because of the changes which manifestly take place in the contained salts, changes so evident that Mr. Balard has been able to base upon them a manufacture of sulphate of soda, by exposing to a temperature sufficiently low the waters containing NaCl and MgO, SO^3, which result from the manufacture of sea-salt by the evaporation of sea water.

The publication of this process has given occasion for a protest on the part of Mr. Tichon, an apothecary of Aix les Bains (Savoy), according to which the same process has been used since 1856, by him and a Mr. Melsens, who was staying at Aix for his health. The mineral water which he drank here, and which is sulphurous, proving disagreeable to his taste, he undertook to remove part of the odor by submitting it to a freezing mixture. In this way he was able, not only to mask the disagreeable odor but also to concentrate the mineral ingredients.

Mr. Tichon adds that congelation will not suit all mineral waters, inasmuch as it alters the organic matter therein dissolved.

Manufacture of ice.—If freezing mixtures were the only means of obtaining ice, or a degree of cold corresponding thereto, the various applications of which we speak would still be far from having received a practical solution, but we already know of important services daily rendered to science by the apparatus of Carré which excited so much interest at the last London Exhibition. As we cannot here describe this interesting machine, for lack of room, we are obliged to refer for particulars to "L'Année Scientifique et Industrielle," by Figuier, 1863, page 457, and Supplement, but the principle is as follows:—It is based upon the great quantity of heat which ammonia, liquefied by condensation, absorbs in becoming again gaseous, as this body contains an immense amount of latent heat.

Ammonia in the gaseous state is readily obtained as is well known, by boiling the ammoniacal liquid known in commerce as "volatile alkali," to reproduce which it is only necessary to expose ammonia in the presence of water; to liquify the gas, simple pressure is adequate. As it so readily takes the gaseous form, it is sufficient to simply remove the pressure which retains it as a liquid, and as this change of state is possible only on the condition that the liquefied ammonia retakes the heat lost in its liquefaction, we perceive that it will rapidly cool the vessel which contains it and, consequently, the neighboring material.

To undertake the method of putting these principles in operation we have only to suppose an apparatus composed of two retorts soldered together by the necks, the whole perfectly close and without communication with the outer air. In the larger of these retorts we place a concentrated solution of ammonia in water and heat it. Driven off by the heat, the gaseous ammonia cannot escape without becoming liquefied in the small retort. But, when the apparatus is restored to the ordinary temperature, the liquefied ammonia reassumes its gaseous form and becomes redissolved in the water of the first retort.

Two forms of apparatus are used, 1st, intermittent, 2d, constant: they are beginning to be introduced into various branches of industry. Brewers use them to freeze the wort of beer destined to undergo fermentation; coffee-house keepers for making ices and sherbets; vine growers to concentrate wine, and in the preceding article we have noticed other uses to which this apparatus has been or can be applied.

Mr. Carré started in this line of business in the first place, by perfecting an apparatus of American invention, [that of Prof. A. C. Twining,] in which the volatilization of sulphuric ether served to produce a considerable degree of cold, and to obtain, in a short time, blocks of ice.

Still, this apparatus presented a great fault, viz: the difficulty of maintaining the vacuum: not being able to remedy this, conveniently, he chose to change the system; thus he was brought to operate his machine with ammonia.

Building Materials—Preservation by means of the residuum of coal-tar.—In France, the residuum obtained by the distillation of tar, for the purpose of extracting the oils and hydrocarbons, is called *brai* (*coal-tar pitch* in English). Upon immersing bricks in this resin, melted at 200°, they become fit to use with success in the construction of chlorine chambers, also of condensers for chlorhydric acid. Mr. Kuhlmann, of Lille, has applied it hot to the exterior walls of his kilns for the decomposition of sea-salt, he also impregnates with it the tiles with which his workshops are covered, especially on those in which acid exhalations are produced. He also employs it for giving consistency and a black color to vessels and tiles of porous earthen ware. Plaster acquires a strong consistency, and does not crack as it does after being dipped in silicate of potash or soluble glass: by virtue of its porosity, it is thoroughly penetrated by the resin, and becomes permeable to all other substances; while objects moulded in plaster retain their form without the least alteration. This is so true that crystals of gypsum (natural hydrated sulphate of lime) become, in the resin, of a shining black color, the crystalline form not being changed, but the water of hydration, being replaced by the resin: it is a pseudomorph. Alabaster acts in the same way.

Stones covered with coal tar, or even with a greasy or resinous coating, resist the action of wind bringing salt spray from the sea better than do bare stones.

Mr. Kuhlman saw a striking example of this in the Bay of Biscay upon a building erected in 1858. Upon the more exposed points, the wrought stones were deeply corroded; but what is most remarkable of those stones which before being put in place, were numbered in black with oil, the parts covered by the color have been so protected from alteration that the numbers are now presented in considerable relief and with great sharpness.

This resin is not the only substance which readily penetrates plaster, stone or masonry. Mr. Kuhlmann has discovered that resins, greasy matter, and various other substances act in the same way, and that it is also the case with all liquids and bodies in fusion, when they *wet* the body which is to be penetrated. In the case of plaster it is not a simple effect of permeability, but rather of displacement of the water; the plaster, becoming anhydrous, is thoroughly penetrated by the tarry matter, and its consistence increases, but the form of the object moulded is preserved unaltered, even when the bath of resin is raised to the temperature of 400° C. At from 150° to 200° C., stearic acid acts like resin; the plaster becomes impregnated with it, and at the same time loses its water of hydration, which is recognized from the boiling which it occasions in the bath.

With liquids which do not wet the plaster, this penetration does not take place. Mr. Kuhlman has tried in vain to effect it with melted sulphur or with mercury.

But it is not only water which can be displaced by coal tar; other substances are similarly affected: e.g., crystallized peroxyd of manganese

loses, in the boiling resin, one atom of its oxygen, and takes up coal tar; its crystalline form remains unchanged; after the operation, the crystals thus treated no longer give any trace of chlorine with chlorhydric acid.

In all these experiments, the temperature of the solid body should be raised very gradually.

Bibliography.

Recent Publications by HACHETTE & Co., Paris:

Leçons faites à la Société Chimique de Paris, par M. Verdet et M. Berthelot. 8vo, 1863. These lectures bear partly upon the great question of the "mechanical equivalent" of heat, which Mr. Verdet has set forth at two sittings and in which he has summed up the state of the question of which the fundamental formula was given forty years ago by Mr. S. Carnot.

Mr. Berthelot, in his lectures, explains all the facts which relate to the polyatomic alcohols, in the discovery of which he has taken so large a part; he then treats thoroughly of the sugars, and the other alcohols whether derived or polyatomic, of which he has equally contributed to increase the list and elucidate the history.

L'Année Scientifique et Industrielle, par L. Figuier, 7th year.—This popular work contains the principal scientific facts made known during 1862. Among other important articles we notice the following:—upon the cutting of the Isthmus of Suez; upon the Mount Cenis tunnel; upon the artesian wells in the Sahara; the metallurgy of platina; textile substances substituted for cotton; machine for making ice; &c., &c.

L'Année Géographique, par Vivien de St. Martin.—1st year, 1863.—The author has begun for geography that which Figuier has accomplished for the sciences. The voyages of discovery, the ethnographical studies, the topographical works, the antiquarian researches of the year are all recapitulated; the excavations at Nineveh and Babylon, the search after the source of the Nile, the journies across central Africa, the triangulation of India, with many other subjects, are treated in a very clear and very complete manner.

Histoire des temps modernes, depuis 1453 *jusqu'à* 1789, *par V. Duruy.* 1 vol. 12mo, 1863. This volume forms part of a collection which is often inquired after, and which appears under the direction of Mr. Duruy, at present the Minister of Public Instruction in France. The present volume is entirely by Mr. Duruy himself, and will give some idea of the liberal as well as philosophical spirit of its author.

This book is a continuation of a series of works by the same author, who is especially celebrated for his philosophical spirit and the independence of his ideas and opinions. Among his collaborators we find such scholars as Chéruel, Guillemin, Preysz and Zeller, from whom we have previously had many publications.

Les marines de France et d'Angleterre—1815–1863, *par X. Raymond.*—The principal chapters of this interesting work are: Steamers—Floating batteries and iron clads—Iron armor and cannon—The conditions of naval power, &c.

Abd-el-Kader; sa vie politique et militaire, par Alex. Bellemare, 12mo. The author, who is a sincere admirer of the Emir, has given careful study to the events in which this great man has taken part. Being attached to his person in the capacity of interpreter, Mr. Bellemare has been able to make a valuable book and one which historians my consult with profit.

Association polytechnique.—Entretiens populaires; 3d series, 1863. 1 vol. 8vo. This new series, following those which we have previously announced, contains lectures upon the Plurality of Worlds, by Babinet; upon the Suez ship-canal, by de-Lesseps; upon Work and its Influence upon Health, by Dr. Bouchardat; then, the lectures upon the London Exhibition; these last were given especially in view of the "Universal Exhibition" which is to take place in Paris in 1867, and which will be much more *universal* than any of its predecessors, in that all branches of human activity will be admitted thereto.

Souvenirs d'un prisonnier de guerre au Mexique, 1854–1855, *par Vigneaux.*—The author was one of the adventurers belonging to the party of Rousset-Boulbon, and served as its secretary. The book is therefore founded on accurate knowledge of this adventurous campaign, at the end of which Mr. Vigneaux found a prison.

L'Intelligence des bêtes, par Victor Rendu, 12mo.—The author, being a great lover of bees, and having viewed his subject with affection, brings up especially

such facts as testify in favor of the intelligence of these useful insects and other Hymenopters. He naturally concludes in favor of the intelligence of animals in general, and gives, in support of his opinions, some very interesting examples.

L'Année Littéraire et Dramatique, par Vappareau, 12mo.—A work of the character of *L'Année Scientifique* noticed above; it treats of all the new literary and bibliographical works which appeared in France in the year 1862.

Fraudes et Maladies du vin, par Jacques Brun. 8vo, 125 pp.—This work, conscientiously written, indicates the ways in which we may discover adulterations and diseases of wines, as well as the process for their analysis, among which are many new ones, some of them invented by the author.

Le Verrier du XIX^{e} *siècle, par Flamen.* 8vo, 500 pp.—This work is a complete treatise upon the manufacture of crown and flint glass, and enamel. The author, who has for a long time directed a large glass manufactory, includes in this work his practical observations and also the secrets of manufacture which have secured the success of his glass as well as of his establishment. Mr. Flamen is not learned —we see it in his book, but he is a practical man, and especially an observer. The processes not before published take up a large part of the book; of these he has invented some and perfected many more.

Nancy, July 5, 1863.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *On the density of vapors at very high temperatures.*—Deville and Troost have communicated the results of their very interesting and valuable investigation of the subject of vapor-densities. If we consider the combining volume of hydrogen as **2**, the volume occupied by an equivalent of chlorid of ammonium is, as is well known, **8**, while the volumes occupied by single equivalents of most compounds appear to be represented by **4**. Many chemists assume that at high temperatures chlorid of ammonium is decomposed into equal volumes of ammonia and chlorhydric acid so that the **8** vols. of the former are really a mixture of **4** vols. of each of its constituents, and the volume **8** is therefore *apparent* only. At lower temperatures, in cooling for instance, the constituents recombine. A similar explanation has been given for other cases of **8**-volume vapors, and Pebal, Wanklyn and Robinson have endeavored to show by the direct application of Graham's method of diffusion that a separation actually does take place at high temperatures inasmuch as small quantities of the **4**-volume constituents were obtained in a free state. Deville has now proved, first, that at the temperature of 350° C. ammonia and chlorhydric acid combine with evolution of heat, so that it is impossible that dissociation can take place at this temperature. Secondly, that chlorid of ammonium does not decompose at a temperature at which ammonia is already in large part decomposed. Thirdly, that a mixture of chlorhydric acid nitrogen and hydrogen, passed through a tube heated to low redness, does not combine to form chlorid of ammonium, even in presence of platinum sponge. Similar experiments made with iodid and bromid of ammonium lead to the same results. Cyanid of ammonium, which is formed at very high temperatures by the contact of ammonia and carbon, occupies **8** volumes at 100°. Even if this salt did decompose it would not give a mixture of cyanhy-

dric acid and ammonia, because both of these are decomposed much sooner than the cyanid. Chlorhydrate of ethylamine is decomposed in very small quantities into ammonia and chlorid of ethyl at high temperatures, but the gases do not recombine under the circumstances. Deville explains the results of Pebal, Wanklyn and Robinson very simply by suggesting that the process of diffusion produces a decomposition of compound gases exactly as of liquids and salts in solution. Deville finds further that the number of substances corresponding to **8** vols. of vapor is much larger than has been supposed. His recent results confirm the view already received that sulphur, selenium, tellurium, phosphorus and arsenic correspond to **1** volume (H=2). The vapor density of chlorid of niobium, $NbCl_2$ (?), corresponds to **2** vols. as well as that of chlorid of tantalum, $TnCl_2$ (?). Neutral sulphid of ammonium and monohydrate of sulphuric acid give **4** vols. of vapor. The authors in conclusion call attention to the danger of basing theoretic speculations on the atomic constitution of bodies upon vapor-densities alone.—*Comptes Rendus.*

W. G.

[*Note.*—It is easy to see that if the existence of 8-volume vapors be admitted, the *molecular* weights of the elements must be made to correspond to 8 volumes instead of to **4**, provided that we assume, with the followers of Gerhardt and Laurent, that the molecules of all substances in the form of vapor, occupy the same volume. The molecular weight of oxygen thus becomes 64 instead 32, and the molecule must consist of 4 atoms, each having a weight represented by 16. While the progress of science may lead to the adoption of the new atomic weights, it is not to be denied that the advantage of simplicity still remains with the older view, which admits the possibility of a difference in the atomic volumes of different gases. W. G.]

2. *On the work of elastic forces.*—In a very interesting and suggestive note on the course to be pursued to discover the only truly universal principle in physical nature, Lamé asserts that he has recently demonstrated, with an unhoped for degree of rigor and simplicity the following propositions. The velocity of propagation of a plane wave in any solid diaphanous medium must diminish with the length of the wave, this diminution being zero when there is no free ether; insensible in all cases of sonorous waves; very sensible on the contrary in the case of a luminous wave, if the ether exists and if the distances which separate the ponderable particles are comparable to the breadth of the wave. In other words, in the formulas employed the coefficients of elasticity, instead of being constant, must contain the length of the wave and diminish with it; this modification is necessary and sufficient. From this second theoretical extension we obtain, first, the only rigorous proof of the existence of free ether in diaphanous bodies, hitherto admitted *à priori* and not demonstrated; secondly, the only completely rational explanation of the phenomenon of dispersion; and thirdly, a whole series of new consequences on dispersive powers, on the coloration of transparent media, on the real distances which separate the ponderable particles and on other points.—*Les Mondes*, 4 *Juin*, 1863. W. G.

3. *On the atomic constitution of liquids.*—Wiener has given an explanation of the motion of small particles of inanimate matter in liquids,

long since observed by the English botanist, Robert Brown. The explanation depends upon the author's views of the constitution of matter and of the relations between material and etherial particles. These views are in themselves worthy of attention as presenting some new points and perhaps overcoming difficulties long since recognized. The author's propositions are briefly as follows:

(1.) Matter consists of material atoms which mutually attract, and of etherial atoms which mutually repel each other. Material and ethereal atoms repel each other.

(2.) The heat of a body consists in a condition of vibration of its ethereal atoms and material molecules.

(3.) With an increase in extent of vibration is connected;

a. an increase of living force in the position of equilibrium.

b. a diminution of the time of vibration.

c. an expansion of the body. For if after the position of equilibrium has existed, vibrations are excited around this, the mean distance of two vibrating atoms is still the same as in the position of equilibrium, but the mean of the varying forces is greater than the force in the position of equilibrium, because the forces diminish in some inverse ratio of the distances. The mean force therefore increases with the extent of vibration, and expansion must ensue.

(4.) The temperatures of two bodies are equal when the times of vibration of the atoms in them are equal.

(5.) The quantity of heat conveyed to a body is the increase of the living force of the vibrating atoms and the work done by the change in the position of the atoms. The living force is here defined as $\frac{1}{2}mv^2$ and not as mv^2.

In the process of fusion heat is absorbed; the work done is expended in changing the physical condition and not in raising the temperature. This work must be commenced either in overcoming internal forces with a change in the position of the atoms, or in producing an increase of living force, and must be accumulated in the body in one of these forms. The first case cannot occur because an increase in the distance of the molecules often does not occur, as for instance in the case of ice, which contracts on melting. The work commenced must therefore be expended in increasing the living force of the vibrating atoms, but here the difficulty arises that there is no change of temperature during fusion.

To overcome this difficulty, Wiener suggests that the difference between the two physical states may consist in two different directions of the vibrations of the ponderable molecules as compared with the directions of the vibrations of the ethereal particles. Thus in the one case the two sets of particles may vibrate in the same, and in the other case in opposite directions. In solid bodies the direction of the vibration of the molecules is opposite to that of the ethereal particles; in fluids it is in the same direction; the latent heat of liquefaction is expended in increasing the living force which is necessary to keep the time of vibration or temperature unchanged during the inversion of the direction of vibration. When the temperature becomes sufficiently high the distance between two molecules may become so great that the range of stable equilibrium is

exceeded, so that the active force has its direction inverted. The molecules then vibrate in the direction of the atoms, and the condition of fluidity is reached while the temperature becomes that of fusion. The new state of vibration does not admit of stable equilibrium, and when two molecules separate beyond the position of unstable equilibrium the intervening ether must dilate, its repulsion for the surrounding ether must diminish, and this will rush in to supply what may be called the partial vacuum. The outer atoms and molecules will follow, and since the cause of this motion, namely the great amplitude of vibration, constantly acts, there will be a constant motion of the particles with respect to each other. In other parts of the liquid the molecules are for an instant within the limits of stable equilibrium, and there is therefore a certain amount of cohesion. The author proceeds to apply this theory to the motions of solid particles observed by Brown: he shows satisfactorily that these are not due to infusoria, to mechanical agitation, to the attraction and repulsion of the vibrating solid particles for each other, to differences of temperature or to evaporation, and ascribes them therefore to internal motions peculiar to the condition of fluidity. In the case of particles whose diameter was between 0·0006 millimeter and 0·0014 millimeter, the mean velocity was 0·0016 millimeter per second. With larger particles the motion was less; thus, particles 0·0023 millimeter in diameter had a velocity of 0·0005 millimeter per second. With particles from 0·0014 to 0·0023 millimeter the motion varied greatly, but was usually considerably greater than 0·0005 millimeter. With a greater diameter than 0·0023 millimeter the motion was still less. The author infers from these measures that the diameter of the similarly moved masses of water is so small as to correspond nearly with the wave-length of red light and still more nearly with that of radiant heat, and considers this as a strong confirmation of his theory.—*Pogg. Ann.*, cxviii, 79. W. G.

4. *On the absorption of gases by charcoal;* by Dr. R. Angus Smith, F.R.S.—The following is a summary of the author's observations:—

(1.) Charcoal absorbs oxygen so as to separate it from common air, or from its mixtures with hydrogen and nitrogen, at common temperatures.

(2.) Charcoal continues the absorption of oxygen for at least a month, although the chief amount is absorbed in a few hours, sometimes in a few seconds, according to the quality of the charcoal.

(3.) It does not absorb hydrogen, nitrogen, or carbonic acid for the same period.

(4.) Although the amount absorbed is somewhat in the relation of the condensibility of the gases by pressure, this is not the only quality regulating the absorption, of oxygen at least.

(5.) When it is sought to remove the oxygen from charcoal by warmth, carbonic acid is formed, even at the temperature of boiling water, and slowly even at low temperatures.

(6.) Charcoals differ extremely in absorbing power, and in the capacity of uniting with oxygen, animal charcoal possessing the latter property in a greater degree than wood-charcoal.

(7.) Nitrogen and hydrogen, when absorbed by charcoal, diffuse into the atmosphere of another gas with such force as to depress the mercury three-quarters of an inch.

(8.) Water expels mercury from the pores of charcoal by an instantaneous action.

(9.) The action of porous bodies is not discriminate but elective.

Theoretical Considerations.

(1.) The elective nature of porous bodies may be closely allied to three properties:—

a. The condensibility of the gases.

b. The attraction and perhaps inclination to combine.

c. The capacity of combination.

(2.) In either case, the attraction which results in condensation of the gas is exercised at distances greater than the distances of atoms or molecules in combination.

(3.) The gases in porous bodies lie in strata, the outside and more distant being less attracted than the atoms nearer the solid body.

(4.) We cannot separate chemical from physical attraction; but attraction may exist without its ultimate result (combination), which is distinctly chemical.

(5.) It is exceedingly probable that as physical attraction moves onwards to chemical combination it produces the phenomena which have been attributed to so-called masses.

Chemical affinity is supposed to involve an attraction which is purely chemical; we have no proof of any such attraction as a separate power, we have only a proof of the combination. Attraction may exist without the capacity of combining chemically, or, in other words, without chemical affinity. Chemical affinity (a very inappropriate term) is only known by combination; the previous attraction has never yet been shown to be of two kinds; and it seems more in accordance with Nature to diminish than to increase the number of original powers.—*Proceed. Royal Soc'y*, Feb. 5, 1863, p. 424.

[John Hunter, of Belfast has published in the *Philosophical Magazine*, (1863) p. 364, the preliminary results of a series of researches on this subject, in which he follows the method of Th. de Saussure, by introducing heated charcoal into the dried gas over mercury and noting the absorption. This part of his paper is devoted to the absorbing power of different kinds of charcoal on ammonia, carbonic acid and cyanogen.

He found that prolonged heating of charcoal diminished its power of absorption, hence all the pieces of charcoal were heated as nearly equally as possible. We condense below his main results, giving the mean of all the trials reduced to 0° C. and 760 mm.

	Ammonia.	Carb.acid.	Cyanogen.
Logwood,	111·3	54·6	87·3
Ebony,	106·7	47.0	89·6
Camwood,	91·2	45·4	
Green Ebony,	90.3	40·8	
Fustic (Cuba),	89·6	58·0	
Lignum vitæ,	89·0	47·2	
Boxwood,	85·6	31·2	28·8

	Ammonia.	Carb.acid.	Cyanogen.
Logwood, (Jamaica)	69·5	33·3	33·3
Sapan wood,	69·9	32·2	32·2
Beach,	58·		
Rosewood,	50·6		
Wistaria Sinensis,	44·03		
Vegetable ivory,	50·5	57·3]	

II. CHEMISTRY.

1. *On Anilin dyes.*—HOFMANN has made the unexpected observation that chemically pure anilin does not yield coloring matters with oxydizing agents. The same is true of pure toluidin. On the other hand, a mixture of anilin and toluidin yields the characteristic colors with great facility, and it therefore appears certain that the coloring matters contain both the phenyl and tolyl molecules. Anilin blue has been found by Hofmann to have the formula $C_{76}H_{31}N_3$; its rational formula is $C_{40}H_{16}(C_{12}H_5)_3N_3$, so that it is to be regarded as rosanilin in which three eqs. of hydrogen are replaced by three of phenyl. Triphenyl-rosanilin, or anilin blue, is prepared by heating rosanilin with an excess of anilin; its formation is represented by the equation,

$$C_{40}H_{19}N_3, HCl + 3C_{12}H_7N = C_{40}H_{16}(C_{12}H_5)_3N_3, HCl + 3NH_3.$$

The free base is a white amorphous substance: the chlorhydrate has a bluish-brown color and dissolves in alcohol with a magnificent blue. The author describes several other salts, all of which are uniacid. Reducing agents convert triphenyl-rosaniline into triphenyl-leucaniline, which has the formula $C_{40}H_{18}(C_{12}H_5)_3N_3$. The iodids of methyl, ethyl and amyl act readily upon rosaniline, forming new coloring matters analogous to aniline blue and containing three equivalents of methyl, ethyl or amyl in place of three of hydrogen. The author promises further communications on the nature of anilin-green, anilin-violet and azulin.—*Comptes Rendus*, lvii, 25. W. G.

2. *On the constitution of American Petroleum.*—PELOUZE and CAHOURS have studied the oil obtained at present in very large quantities in Pennsylvania, and find that it consists essentially of homologues of marsh-gas, the lowest term of the series obtained being hydruret of butyl, C_8H_{10}, which boils at a little above 0° C., while the highest term yet studied is $C_{30}H_{32}$. The authors have obtained from these hydrurets the corresponding chlorids and in many cases the alcohols. They consider it probable that paraffin is a mixture of still higher terms in the series. Similar results have been obtained by Schorlemmer, who however finds benzol and toluol in the American oils, while Pelouze and Cahours explicitly deny the presence of these substances.—*Comptes Rendus*, lvii, 62. W. G.

3. *On Cæsium, separation from Rubidium.*—BUNSEN (*Pogg. Ann.*, cxix, 1) has made further investigations on this rare element. He could not apply Allen's method to the preparation of pure cæsium compounds because of the small quantity of the element obtainable from the sources at his command. He discovered that cæsium could be separated from rubidium by another plan, which is as follows: In a mixture of pure RbCl and CsCl the Cl is determined, and from its amount that of Rb is calculated. The chlorids are converted into carbonates, and to the latter salts a little more tartaric acid is added than is necessary to produce neutral tartrate of cæsium and bitartrate of rubidium. The mixture dried and pulverized is brought upon a funnel whose neck is stopped by a small filter, and the whole is placed in an atmosphere saturated with moisture. The neutral cæsium salt deliquesces and passes the filter while the acid rubidium salt remains behind.

Equivalent.—The cæsium tartrate was converted into chlorid and the latter was purified from traces of KO and LiO, which it acquired from the tartaric acid, by conversion into platin-chlorid, washing, &c. This operation was repeated six times, the salt being each time analyzed. The last three results coincided very closely, and from their average the equivalent 132·99 was deduced, which agrees with the number obtained by Johnson and Allen, viz: 133·03, and fully authorizes the use of the round number, 133, as expressing the combining proportional of this element.

Deliquescence of CsCl.—Bunsen further maintains the accuracy of his original assertion that CsCl is deliquescent. Johnson and Allen had stated that it was "not only not deliquescent but scarcely hygroscopic." The observations of both are entirely correct for the circumstances under which they were made. We have since observed pure CsCl to deliquesce in a few moments on an August day; while at this writing, Sept. 24th, the same specimen has been exposed all night to the air in a room with open windows, temp. 55° F., and is in appearance perfectly dry. Bunsen rightly remarks that "Johnson and Allen appear to have made their experiments in a comparatively dry atmosphere, in which as is known many deliquescent salts are unaltered, and therefore overlooked the deliquescent character of CsCl." The experiments of Johnson and Allen were made in the cloudy and foggy but cold weather of November, weather which is commonly designated as *damp*, but the real moistness of the atmosphere they only judged of from sensation.

CsCl much resembles urea in its hygroscopic relations. The latter substance is stated by most recent authors, including those who have had occasion to observe it especially, *to be unaltered in the air.* Thus Lehmann, *Physiological Chemistry;* Gorup Besanez, *Zoochemische Analyse;* Mitscherlich, *Lehrbuch;* Gerhardt, on authority of Pelouze, *Traité de Chimie Organique;* and Neubauer, *Analyse des Harns*, assert that it is unchanged by exposure to the air. Gorup Besanez, *Lehrbuch der physiologischen Chemie*, 1862, states that it is "permanent in the air but rapidly absorbs moisture." Gmelin mentions that "according to earlier statements it deliquesces in moist air." We have repeatedly observed that in very moist air urea rapidly deliquesces, though usually, except in summer weather, it is not visibly affected by atmospheric moisture.

Spectrum of Cæsium.—Johnson and Allen, in the paper above referred to, observed that "Kirchhoff and Bunsen, in the figure given by them (*Pogg. Ann.*, 1861, and *Fres. Zeitschrift für analyt. Chemie, Heft* 1, 1862), represent 11 lines. We find without difficulty 7 more lines, and observe further that some of those figured by K. & B., are not mapped in their correct position."

In relation to this, Bunsen remarks, "we regret that Messrs. J. & A. appear to have neglected to make an accurate comparison of their spectrum with ours, otherwise they would have easily convinced themselves that the lines given by them agree with ours as closely as is possible: that on the other hand three lines are figured on our plate which do not occur at all in the cæsium spectrum. These lines have been printed on a number of lithographs by fault of the lithographer, in consequence of a

misunderstood proof that was not sent to us for revision, and lie near and to the right of the lines designated by J. & A. as VI, X and XV."

Johnson and Allen could but conclude that the colored plate in *Poggendorff's Ann.*, accompanying the paper of Kirchhoff and Bunsen, was a copy of their spectrum as far as the important, i. e., the characteristic and brilliant, lines were concerned. They are therefore scarcely more in fault in having "neglected to make an accurate comparison" than K. & B. are in permitting incorrect spectrum plates to be circulated. Fresenius uses the uncorrected chromo-lithograph in the new edition of his *Qualitative Analyse*, and we have never yet had the good fortune to see the lines of this element correctly mapped on any colored print.

Bunsen notices at length the inaccuracies of the diagram of J. & A., which, as the latter stated distinctly, was intended to give *approximatively* the position of the lines on Kirchhoff and Bunsen's scale, and which from the construction of the spectroscope they employed would not be exact.

The remark of J. and A. that their "line II, nearly coincident with α lithium of Kirchhoff and Bunsen, and not figured by them, is as bright as their γ cæsium, our VI (?)"—Bunsen passes over without notice. The observation is certainly not an unimportant one, for any person occupied in preparing the new alkalies is likely to be embarrassed by a line that in small instruments is practically coincident with α lithium, if it be not credited to cæsium by the authorities.

Johnson and Allen rightly state that "the yellow line VIII, is hardly less characteristic of the spectrum of *pure* cæsium than the two blue lines. It also is nearly as distinct as any of the green lines when sodium is not present in too large quantity, and is much more readily made out than the extreme red line δ of rubidium." This line was wanting in the original spectrum plate of K. & B. Chemists will be glad that Bunsen has now given, in connection with the paper we refer to, a diagram of the spectra of all the alkalies and alkaline earths, as well as of thallium, which is quite complete, and which, by following his simple directions, is readily and exactly comparable with the spectra of any instrument. In this he figures 16 lines for cæsium. S. W. J.

4. *Preliminary Notices of a New Metal;* by F. Reich and Th. Richter.—The authors have found a new metal in two Freiberg ores, which were composed principally of arsenical pyrites, blende, and some galena, together with silica, manganese, copper, and a small proportion of tin and cadmium. The ores were first roasted to get rid of the greater part of the arsenic and sulphur, then mixed with chlorhydric acid, evaporated to dryness and distilled. The impure chlorid of zinc obtained was examined with the spectroscope for thallium. No green line was seen, but the authors remarked an indigo-blue line, which was before unknown.

The authors succeeded in isolating the conjectural substance, necessarily in very minute quantity, partly in the form of chlorid, partly as hydrated oxyd, and partly in the metallic state. On submitting these, moistened with chlorhydric acid, to the spectroscope, the blue line was seen so brilliant, sharp, and persistent, that they did not hesitate to conclude that it belonged to a hitherto unrecognized metal, to which they accordingly gave the name *Indium*.

The line mentioned has a perceptibly greater refrangibility than the blue line of strontium, and there appears besides a much weaker line, of still greater refrangibility, which almost, but not quite, reaches the blue line of calcium.

The authors add that as far as they have examined the chemical properties of *Indium* they may safely assert that it is not precipitated from an acid solution of the chlorid by sulphuretted hydrogen; that from the same solution it is precipitated by ammonia as a hydrated oxyd; that the chlorid is extremely deliquescent; and that the oxyd heated on charcoal with soda gives lead-gray metallic beads, which are ductile and very soft; these heated again before the blowpipe give a yellowish coating, which on further heating takes no characteristic color with cobalt solution.—*Journal für Praktische Chemie*, lxxxix, 441, *from Chemical News*, Sept. 12, 1863.

5. *On some new volatile alkaloids given off during putrefaction.*—Dr. Crace Calvert communicated under this title to the Royal Soc'y (Feb. 1860) the preliminary results of some investigations on the products of putrid wounds, with reference to the contagion known as hospital gangrene. We have waited the conclusion of his research, but as it has not yet appeared we give the main points of his first paper. Failing to obtain a sufficient supply of the products emanating from putrid wounds, he arranged, in each of a number of small casks, twenty pounds of meat and fish, mixed with pumice stone to prevent clogging. Two tubes were adapted to the top of each cask, one of which supplied air, which was drawn through the other from near the bottom of the cask by an aspirator. The air in its passage passed through two bottles containing chlorid of platinum, which was soon made turbid by the production of a yellow amorphous powder. This precipitate collected, washed with water and alcohol, and dried, was found by analysis to contain carbon, hydrogen, and nitrogen, but what was remarkable sulphur and phosphorus also entered into its composition. The amount of these elements determined quantitatively was 11 per cent for the sulphur and 6·01 per cent of phosphorus, of the whole precipitate. By heating a quantity of the platinum salt with a strong caustic ley, a liquid, volatile and inflammable alkaloid was obtained, whilst sulphur and phosphorus remained combined with the alkali, and were easily detected. The author is satisfied from twelve months research that no sulphuretted or phosphoretted hydrogen was given off, and his researches tend to prove that the noxious vapors given off during putrefaction contain the nitrogen, sulphur, and phosphorus of the animal substance, and that these elements are not liberated in the simple form of ammonia, and sulphuretted and phosphoretted hydrogen. As putrefaction proceeds, different volatile bodies are given off. The platinum salts, heated in test tubes, give off vapors, some acid, some alkaline, of a most noxious and sickening odor, resembling putrefaction, while a white crystalline sublimate is formed, which is not salammoniac. These researches are still in progress and will occupy several years.

Photography.—

6. *Selenocyanids in Photography.*—Mr. Emerson J. Reynolds has studied the action of selenocyanids in photography, and finds that it is similar to that of the sulphocyanids. An aqueous solution of seleno-

cyanid of potassium gives a white curdy precipitate in a solution of nitrate of silver soluble in an excess of the precipitant, and the same solution will remove the trace of silver compounds present in the whites of albuminized prints after fixing with hyposulphite. While, however, the dilute acids were without action on the sulphocyanids of the alkaline metals, they decompose the corresponding selenium compounds. Selenocyanid of silver is insoluble in water, nearly so in solution of ammonia, and almost unacted on by dilute acids. It is less sensible to light than chlorid of silver, but more so than sulphocyanid of silver.—*British Journal of Photography*, x, 223.

7. *A process for the reduction of silver waste* has been discovered by MILLON and COMMAILLE which promises to be of practical value. It is based on the fact first observed by these chemists, that ammoniacal subchlorid of copper precipitates completely perfectly pure silver from a solution of nitrate of silver to which a slight excess of ammonia has been added. In the first place, the ammoniacal subchlorid of copper is prepared by dissolving 5 parts of black oxyd of copper and 4 parts of finely divided metallic copper in chlorhydric acid. When the whole is dissolved, an excess of the strongest liquid ammonia is added, which produces a clear and colorless or pale blue solution. If it be used to reduce an old bath, it is only necessary to add ammonia until the oxyd of silver is redissolved, then pour in an excess of the copper solution, and collect, wash and dry the pure reduced silver. The same reagent may also be used for reducing the silver of an old hyposulphite bath, only in conducting this process it is important to observe the following precautions: 1st, not to add too much ammonia; 2d, to have the mixture greatly diluted; 3d, to allow sufficient time for the finer metallic particles to settle completely to the bottom.—*London Journal of Photography*, x, 246.

8. *Sulphocyanid of ammonia as a fixing agent.*—Experiments have been made by G. W. SIMPSON and Mr. LEWITSKY on sulphocyanid of ammonia as a fixing agent, employing a saturated solution of the salt for the purpose. The results seem to indicate a marked superiority over hyposulphite of soda, both as to the sharpness and the permanency of the print. The comparatively high price of the salt must, however, for a long time prevent its general use, but Messrs. Gavin and Cie announce that they can furnish it for four francs the kilogram (about thirty-seven cents a pound), and it seems highly probable that with a large demand the price may be still further reduced.—*British Journal of Photography*, x, 247, 264, also *Le Moniteur de la Photographie*, 3e Année, No. 5, p. 35, and No. 7, p. 51.

9. *Redevelopers.*—(*a.*) Mr. BLANCHARD recommends for redeveloping negatives:

Green vitriol, ...	1 gramme.
Citric acid, ...	2 "
Water, ...	100 "

This intensifier is used just like the pyrogallic acid solution, adding to it a small amount of solution of nitrate of silver, and pouring it on the negative already developed with the usual iron developer. The advantages claimed over pyrogallic acid are that the solution keeps better

(improves, indeed, with age), and does not stain the negative, and that the silver is deposited in a finer condition.

(*b.*) Mr. Simpson recommends the following formula:

Green vitriol,	5 grammes.
Tartaric acid,	1 "
Water,	160 "

A mixture of this solution with nitrate of silver remains clear until full intensity is obtained.

(*c.*) Mr. Linsay uses for developing the negative the usual iron developer, and then adds to it, for intensifying, a small quantity of the following solution:

Citric acid,	3 grammes.
Nitrate of silver,	3 "
Distilled water,	100 "

—*Le Moniteur de la Photographie*, 3e Année, No. 9, p. 67.

[We have used a formula similar to the last with the best results.—J. P. C., JR.]

(*d.*) To these we may add the following formula from Mr. Liefert, a French photographer residing at San Francisco, of a developer which at once gives to negatives on a bromo-iodized collodion all the intensity desired. Dissolve together

Green vitriol,	30 grammes.
Purified nitre,	7·50 "
Water,	420 "
Add Acetic acid, No. 8,	30 "
Alcohol at 32°,	7·50 "
Silver bath at 10 p. c.,	15 "

—*Le Moniteur de la Photographie*, 3e Année, No. 7, p. 49.

(*e.*) Mr. Charles Waldak recommends the following developers for positives on glass, the first rendering the whites dead, and the second making them brilliant and metallic:

For the dead whites.

Green vitriol,	5·30 grammes.
Water,	177·00 "
Acetic acid, No. 8,	7·00 "
Alcohol,	5·00 "
Pure nitre,	2·00 "

For brilliant or metallic whites.

Green vitriol,	4·50 grammes.
Water,	350·00 "
Acetic acid, No. 8,	3·50 "
Alcohol,	5·30 "
Pure nitre,	1·75 "
Solution of nitrate of silver (ordinary bath),	1·75 "
Nitric acid,	20 drops.

The second, of course, acts less rapidly than the first.

5. *Miscellaneous facts.*—Among the other facts worthy of notice in recent photographic journals are:—

(1.) Use of formic acid in developer for instantaneous views, but with somewhat discordant testimony as to its value.

(2.) Methods of separating the albuminous film from the positive print and applying it to the surface of porcelain or other ware, when the gold and silver image may be burnt into the enamel. Similar effects have also been obtained with carbon prints.

(3.) Substitution of the double sulphate of iron and ammonia for green vitriol in the developer (5 parts of the salt, 20 parts of No. 8 acetic acid, to 100 parts of water), which is said to have important advantages over the usual developer.

(4.) In the wet process, after removing the plate from the silver bath, sinking it in a large bath of distilled water, and, just before using, dipping again in the silver bath. The sensibility is said to be thus increased 50 to 100 per cent, and freedom from pin holes and stain to be better insured.

(5.) A new process for printing positives is said to have been invented by Mr. Wothly, in which chlorid of silver is replaced by less expensive materials, and the cost reduced 70 to 80 per cent, with the very great increase of sensibility; but the details were not given, as the author wishes to secure his interest by patent.

(6.) The use, in the tannin process, of acetic acid in the silver bath (2 to 4 per cent of crystallizable acid). The same photographer, Mr. Teissure, recommends the use of a large amount of acetic acid in the developer, which protects the white of the image, and also dipping the plate in the silver bath just before developing, and after it has been dipped into distilled water. J. P. C., JR.

III. AGRICULTURAL CHEMISTRY.

1. *On the fertilizing action of Gypsum.*—DEHÉRAIN, in a note presented to the Academy of Sciences at Paris (*Comptes Rendus*, 18 May, 1863), gives the results of some new studies on this much discussed question. The idea that plaster favors the production of nitre in the soil is not sustained by Dehérain's experiments, as he found that nitrification went on as slowly in plastered soil as in soil destitute of gypsum.[1] He also found that gypsum is without influence in assisting the formation of ammonia in the soil, and unlike caustic lime, does not favor the solution of phosphates.

Convinced that the fertilizer in question operates almost exclusively by its effects upon the soil, and observing that those crops which are most benefitted by plastering, viz: the Leguminosæ, contain a large amount of potash, Dehérain was led to inquire whether gypsum exercised any solvent effect on this substance in the soil. For this purpose a variety of soils were examined, 1st, in their natural state, and 2d, after mixture with 10 per cent of gypsum,—this large quantity being employed to bring

[1] The practice of farmers in some parts of Switzerland (Berne) sufficiently indicates that gypsum has a preservative instead of an oxydizing effect on organic matters. By its use, stable dung, it is said, may be kept quite fresh and unaltered for a whole year, though it acquires an odor of sulphuretted hydrogen. S. W. J.

out any result the more sensibly. Some of the soils were also limed, but, while in the plastered soils a decided quantity of potash was made soluble in cold water, in the limed soils no such effect was produced.

The subjoined table includes Dehérain's results:—

Grammes of potash extracted by cold water from 1 *kilog. of air-dried soil.*

Soils.	From the normal soil.	From the plastered soil.	Difference.	Duration of the experiment.
Black earth of Russia, *Tschernosem*,	0·048	0·136	+0·089	4 months.
"	0·048	0·140	+0·092	15 days.
"	0·048	0·288	+0·240	1 month.
"	0.048	0·428	+0·380	1½ "
Black earth, another specimen,	0·128	0·138	+0·010	1 "
Soil from Chapelles,	0·017	0·115	+0·098	1 "
" Verclives (asparagus bed),	0·487	0·556	+0·069	1 "
" Rio-Parana,	0·003	0·067	+0·064	1 "
" Sologne,	0·192	0·202	+0·010	1 "
" Jardin des Plantes,	0·046	0·355	+0·309	24 hours.

The above experiments were made on such soils as happened to be at hand. Other trials were afterwards instituted on such soils as experience had taught were either considerably benefitted or quite unaffected by plastering. The results were as follows:—

Grammes of potash extracted by cold water from 1 *kilog. of air-dried soil.*

Soils.	Potash in the normal soil.	Potash in the plastered soil.	Difference.	Duration of the experiment.
Soil from Eragny—never plastered.	0·084			
" Alfort "	0·082			
" Gueritaude—plastered with great advantage,	traces.	0·105	0·105	12 hours.
" Gueritaude, another specimen,	traces.	0·192	0·192	" "

Dehérain remarks that these experiments fully establish the fact that gypsum acts by liberating potash, and explains why wood-ashes are often substituted for plaster to advantage, for they afford a direct supply of potash: finally, he gives as a reason of the utility of sowing plaster on the growing crops, that the potash is rendered soluble at a time when the plant can take it up, and is not washed out of the soil as it might be (?) if the latter were not occupied by vegetation.

In regard to the mode in which gypsum favors the solubility of potash, Dehérain refers to the experiments of Huxtable & Thompson, Way, and Brustlein, on the absorptive power of soils, who found that the soil, while it retains in solution, certain substances that may be brought in contact with it, allows others to pass through more or less completely. In repeating these experiments, Dehérain found that plastered soils in general permitted the filtration of saline matters more readily than normal soils, and this effect was especially true of carbonate of potash. In a comparative experiment made on plastered and unplastered soil from Indre-et-Loire, put in contact with carbonate of potash, the result was that the normal soil retained all but traces of alkali, while the plastered soil allowed 0·472 grm. to pass it.

Other researches led to the discovery that *bicarbonate of potash* is scarcely more retained by normal than by plastered soils.

Note.—We venture to assert that the action of gypsum upon the soil is more complicated than appears from Dehérain's experiments, and it is greatly to be regretted that his analyses were not extended to embrace all the changes effected by gypsum. Dietrich, in an extended study of the solvent influence of various agents on soils and rocks, has anticipated Dehérain in the discovery of the general fact that gypsum liberates alkalies from some of their combinations which may occur in the soil. He found that sulphate of lime kept in moist contact with powdered basaltic rock for a few days makes soluble a considerable amount of alkalies.

In his experiments, 100 grms. of powdered basalt were mixed with 10 and another equal portion with 20 grms. of gypsum, and the mixtures were kept moist at the ordinary temperature for ten days. Each mixture was then treated with its own weight of water and immediately filtered. In the first solution were found 0·125 grm. and in the second solution 0·175 grm. of alkali-chlorids. In another experiment 100 grms. basalt-powder were boiled 9 hours in 300 c. c. water with 10 grms. gypsum. In the filtered liquid were found 0·337 grm. alkali-chlorids.—*Jour. für Prakt. Chem.*, lxxiv, 129, 47.

The mode in which gypsum acts in liberating potash doubtless belongs to that class of substitutive reactions which Way and Eichhorn first distinctly brought to notice. The writer, in an article on "Some Points of Agricultural Science" (this Jour., July, 1859, pp. 71–85), gave a notice of the researches of Way and Eichhorn, and adduced other instances of similar actions. Wolff found that the ashes of buckwheat-straw which was raised on a soil manured with common salt contained less chlorid of sodium and more chlorid of potassium than ashes grown on the same soil without this addition, a displacement of potash by the soda having occurred in the soil. Eichhorn found a similar substitution of soda and ammonia for potash in a soil by treating it with solutions of common salt and carbonate of ammonia, (*Wilda's Centralblatt*, 1858, ii, 171). These results were confirmed and extended by Dietrich, *loc. cit.*, by Voelcker (*Jour. Roy. Ag. Soc. of Eng.*), and by all other investigators who have made a thorough study of the absorbent power of soils. From these and other facts mentioned in the paper referred to, the writer concluded as follows: "However complicated and obscure these reactions may be, it is plain, that, henceforth, *the effect of a solution of one base in displacing other bases from native hydrated aluminous and ferric silicates, and of one acid upon the compounds of other acids with oxyd of iron and alumina, must be considered in the theory of the action of saline manures.*"

In a course of lectures on Agricultural Chemistry, delivered at the Smithsonian Institution, the writer remarked that—"the facts brought to light by the researches of Way, Eichhorn, and Voelcker, already described, indicate another general mode by which fertilizers, especially soluble saline bodies, may operate indirectly. The investigations referred to show that the bases (and acids?) may replace each other in insoluble or slightly soluble combinations, *i. e.*, soluble lime may displace insoluble potash, making this soluble and becoming insoluble itself. Soda may, in the same manner, displace lime or potash, or ammonia, the rule being

that the body *in excess* goes into combination, and expels those before combined. We observe here a tendency to bring all the bases into what we may designate as an equilibrium of solution. This principle appears adapted more than any other yet discovered to generalize the phenomena of indirect action, and to enable us to foresee and explain them."—*Smithsonian Report* for 1859, p. 192.

Further investigation will very likely demonstrate that the solvent effects of gypsum are not confined to potash, but also extend to magnesia and in some cases also to phosphoric acid.

There is another mode in which gypsum acts that in many cases is perhaps no less influential than the one just noticed. In the writer's 4th Smithsonian Lecture (p. 191 of the *Report*) may be found the following passages:

"Gypsum, common salt, carbonate of lime, nitrates of potash and soda, and in fact all the saline compounds which are incorporated with the soil in manures, may exert important physiological effects on the plant in addition to their mere nutritive function.

The transpiration of water through the plant is very remarkably hindered when lime, potash, or the salts just named are present in the absorbed liquid. This fact, observed for the first time by Mr. Lawes, in 1850, and recently brought again more strikingly into notice by Dr. Sachs, of Tharand, Saxony, appears to be of great importance in the theory of manures. Dr. Sachs experimented on various plants, viz: beans, squashes, tobacco, and maize, and observed their transpiration in weak solutions (mostly containing one per cent) of nitre, common salt, gypsum, (one-fifth per cent solution) and sulphate of ammonia. He also experimented with maize in a mixed solution of phosphate and silicate of potash, sulphates of lime and magnesia, and common salt, and likewise observed the effect of free nitric acid and free potash on the squash plant. The young plants were either germinated in the soil, then removed from it and set with their rootlets in the solution, or else were kept in the soil and watered with the solution. The glass vessel containing the plant and solution was closed above around the stem of the plant by glass plates and cement, so that no loss of water could occur except through the plant itself, and this loss was ascertained by daily weighings. The result was that all the solutions mentioned, except that of free nitric acid, quite uniformly retarded transpiration to a degree varying from 10 to 90 per cent, while the free acid accelerated the transpiration in a corresponding manner.

As the processes of elaboration—the chemical and structural metamorphoses going on within the cells of the plant—require time for their performance, we can easily perceive that a too rapid upward current of liquid, by diluting the juices, might measurably interfere with the assimilation of the food, and that the presence of a body may be no less useful by its regulating influence on the circulation of the water than by contributing an ingredient necessary for the formation of the substance of the plant itself.

It is also obvious that if a substance added to the soil retard the transpiration of water through vegetation, a given store of hygroscopic moisture in the soil will serve the needs of vegetation longer—will reach

further into time of drought than it otherwise could. Dr. Sachs found that gypsum exerted the greatest effect in preventing loss of water, and this observation gives a scientific ground of evidence to the opinion long maintained among farmers, but rejected by men of science (and very properly, as no cause could be discovered for such an effect, and the effect is not capable of measurement in field culture), that gypsum has the influence of a body that attracts moisture."

Since the above was written, we find that Liebig has also anticipated Dehérain in the discovery that potash is liberated from the soil by the action of a solution of gypsum. From 1000 grms. of soil from a wheat field, 3 liters of pure water extracted ·0243 grm. of potash, while the same amount of saturated solution of gypsum removed from the same quantity of soil ·0436 grm. or nearly twice as much potash. *Die Naturgesetze des Feldbaues*, p. 360, 1862. Liebig also observed (*loc. cit.*) that *magnesia* is liberated by gypsum to a considerable degree. His results are given in the following table.

From 300 grms. of soil are dissolved by a liter

	of distilled water.	of gypsum water.
	grms. of magnesia.	
Soil of Bogenhausen, - - - -	0·0302	0·0706
" Schleissheim, - - - -	0·0316	0·0878
Subsoil of Bogenhausen, - - - -	0·0122	0·0842
Soil of Botanical Garden, - - -	0·0454	0·1686
" Bogenhausen, No. I,[2] unplastered, -	0·0266	0·1016
" " No. II,[2] plastered, -	0·0382	0·0480
" Schornhof, - - - - - -	0·0086	0·0634
" Alabama cotton field, - - -	0·0019	0·0038

Liebig contents himself with communicating the simple results of his experiments without venturing to draw any definite conclusions from them. We remark that they fully confirm our views above expressed.

S. W. J.

IV. MINERALOGY AND GEOLOGY.

1. *On the phosphatic (or guano) rock from the Island of Sombrero, W. I.*—A specimen of the phosphatic rock from the Island of Sombrero has been described by Dr. T. L. Phipson[1] as a new mineral species under the name "*Sombrerite*."

The characters given by Phipson are as follows:—

"Sombrerite presents itself in nature as a white, yellowish white, or reddish colored rock, having a straight fracture, and, in some portions, a peculiar horny aspect; its appearance is, in general, compact, though in reality the rock is very porous. It shows no signs of crystallization whatever, but appears like an amorphous, gelatinous phosphate that has been submitted to a high temperature. It is thought to be of comparatively recent geological origin, as it encloses fossil bones (of mammalia?) and several kinds of shells. In a mineralogical point of view, sombrerite is a compound of phosphate of lime with phosphate of alumina; in some specimens a portion of the alumina is replaced by a corresponding proportion of sesquioxyd of iron; in others, where little or no iron is present, the mineral adheres to the tongue like other

[2] This soil is one whose productiveness is greatly enhanced by plastering.

[1] *Journal of the Chemical Society*, xv, 277.

aluminiferous minerals. Sombrerite is not phosphorescent by heat like apatite; before the blowpipe, when moistened by sulphuric acid, it colors the flame pale green. It contains no fluorid or chlorid of calcium.

The specific gravity of sombrerite is 2·52. A well chosen specimen has given me the following composition:—

		Atomic ratio.	
Water,	9·00	1·00	20
Phosphate of lime $\dot{C}a^3\ddot{P}$,	65·00	0·41	8
Phosphate of alumina $\ddot{A}l^2\ddot{P}^3$,	17·00	0·05	1
Carbonate of lime,	5·00		
Chlorid of sodium,	1·44		
Sulphate of lime,	1·36		
Silica,	1·00		
Crenate of ammonia, &c.	0·20		
	100·00		

The formula of sombrerite is therefore $8\dot{C}a^3\ddot{P}+\ddot{A}l^2\ddot{P}^3+20\dot{H}$."

Dr. Phipson asserts that this compound forms a large portion of some small islands in the West Indies, especially of Sombrero Island. As this statement is at variance with the facts known to those who have had the opportunity to see any considerable amount of the phosphatic rock from Sombrero, we here insert the following observations on Dr. Phipson's article, communicated to us by Mr. Alexis A. Julien, *resident chemist at Sombrero.*

2. *Observations on the Sombrero Guano;* by A. A. Julien.—In anticipation of a paper on the subject of the guano Island of Sombrero, which I hope soon to present, it is proper for me, from my peculiar advantages, to point out some of the errors into which Dr. Phipson has fallen in this proposal to distinguish the Sombrero guano as a new mineral species.

He commences by saying: "This mineral forms a large portion of some small islands in the West Indies, especially of Sombrero Island." The only other islands in the West Indies, besides Sombrero, on which the rock guano has been found to occur, are Les Monges, El Roque, etc., off the coast of Guiana and Venezuela. The composition of the rock guano, however, from these islands is very variable, and, as the published analyses show,[2] differs materially (except in general character) from that of the Sombrero guano, and altogether from the representative analysis for "Sombrerite" which Dr. Phipson offers further on.

In the course of the brief and very imperfect description of the physical characters of the Sombrero guano given by Dr. Phipson, he says: "It shows no signs of crystallization whatever, but appears like an amorphous gelatinous phosphate that has been submitted to a high temperature." I have recently, however, discovered in certain localities small but perfect crystals of bone phosphate of lime, (together with a small proportion of carbonate of lime and phosphate of magnesia,) in the examination of which I am now engaged. Again, there is a natural division of the Sombrero guano into two varieties. One of an *oolitic* structure, of a great variety of colors, and containing, in addition to the bone ($3CaO, PO^5$) and neutral ($2CaO, HO, PO^5$) phosphates of lime, the

[2] This Journal, [2], xxii, 299, 1856. *Proc. Phil. Acad. Nat. Sci.*, March, 1857. This Journal, [2], xxiii, 120, 1857. *Appleton's Encyc.*, article "Guano."

phosphates of alumina, iron, and magnesia, organic matter, silica, etc. The *other* variety, generally of a broad *concretionary* structure, is of a white or yellowish-white color, containing a little carbonate of lime, sulphate of lime, etc., but especially abounds in bone phosphate of lime. From these and other evidences, it is almost certain that the former more nearly resembles the original deposit and is the older of the two; while the latter is far more uniform in composition. These varieties are so characteristic that it would be difficult to find a block of this guano of a cubic foot in dimensions in which one or both of them would not be perceptible. The term "amorphous" can only be applied to those comparatively rare varieties in which these characteristics are mixed, or entirely indistinguishable on account of the uniformity in color of the oolitic grains and their cement. Again, as the guano is interlaminated with ordinary coral limestone, and I have found all the phenomena it presents to be plainly attributable to atmospheric agents, there is no call for the conjecture of a "high temperature," nor for the following strange theory proposed in the latter part of the article: "I look upon this rock as having found its way to the surface at a high temperature, in contact with water or steam, and under great pressure."

The "several kinds of shells," which Dr. Phipson then mentions among the fossils enclosed in the guano, belong entirely to the coral limestone which is very generally converted into phosphate of lime, wherever it is in contact with the masses of guano, or has been exposed in the veins to percolating guano solutions. The only synchronous fossils of the guano, yet discovered, are a variety of bones, the shells of a crab, rootlets, and a small coral.

As a representative analysis of "Sombrerite," Dr. Phipson offers that of "a well chosen specimen,"—the absurdity of which expression will be understood from what has been already stated. The Sombrero guano is as variable in composition, particularly in its content of earthy phosphates, as any other phosphatic guano, and as little entitled to rank as a new species. Dr. Phipson cannot possibly have examined with any care a single cargo,—I venture to say, not even a single *ton;* for there is no natural standard by which a representative specimen could be "well chosen" or chosen at all.

Further, Dr. Phipson does not inform us of the methods used by him in his analysis. This omission is unfortunate when we take into account the prevailing uncertainty among chemists as to the most exact mode of estimating phosphoric acid, in the presence of lime, iron, and alumina, also on account of some other curious results arrived at. Firstly, as to the 9 per cent of water: it is to be presumed that the "well chosen specimen" was carefully dried to remove moisture, which varies several per cent in different varieties. It is also to be presumed, from the analysis, that "Sombrerite" contains no neutral phosphate of lime, with which a part of this 9 per cent of water may be combined,[3] and that the two equivalents of water, combined in the "sulphate of lime," have been deducted from the gross amount. The variety of this guano which I

[3] Notwithstanding that the presence of phosphoric acid in the filtrate, after long washing with hot water, has proved the existence of this salt in at least some common varieties.

have described as of concretionary structure especially predominates throughout the southern part of Sombrero Island, and over one-half our cargoes are composed of it. It contains on an average 83 to 85 per cent of bone phosphate of lime—*less than one per cent of phosphate of alumina and often none.* We may very properly ask if this fact is to be entirely ignored in the consideration of the composition of "Sombrerite"!

The article concludes with the following objection to the use of this guano in the manufacture of superphosphate of lime: "In producing the latter, Sombrerite gives rise to a certain quantity of sulphate of alumina, and this salt, being deliquescent, attracts and retains so much moisture that the product can be dried only with great difficulty,"—an objection applicable with the same force to the 1·44 per cent of similarly deliquescent chlorid of sodium. But every practical chemist is aware that in this manufacture only a portion of the phosphate of lime of the material is ever intentionally and actually converted into superphosphate. It cannot be that Dr. Phipson supposes that this "sulphate of alumina" can be formed and exist in the presence of an excess of bone-phosphate of lime. Finally, he has but to consult that same "manufacturer of superphosphate of lime" to learn how utterly groundless is his objection *in fact* as well as in theory.

Such of these observations as depend merely upon my own statement I shall hereafter more fully elucidate. We may safely conclude that a material so heterogeneous as the Sombrero guano does not possess the uniformity of composition requisite for distinction as a mineral species.

2. *On the nature of Jade, and on a new mineral species described by Mr. Damour;* by T. Sterry Hunt, F.R.S. (From the *Comptes Rendus* of the French Academy of Sciences, June 29, 1863).—"The name of jade was given by the elder De Saussure to a compact whitish mineral from Switzerland, which, as it occurs in rolled masses on Lake Leman (Geneva), was called by Delameter, *lemanite*, and had been described by Haüy as a variety of feldspar, forming with smaragdite the rock to which the founder of crystallography gave the name of euphotide. This jade, according to De Saussure, scratched quartz and had a specific gravity of 3·32–3·40. It was not attacked by acids, and yielded De Saussure by fusion a soft glass, having a density of 2·8. The younger De Saussure afterwards gave to the jade described by his father the name of Saussurite. Subsequently to this, Boulanger, and afterwards Delesse, submitted varieties of euphotide for examination. These chemists mistook for saussurite a white mineral often presenting the cleavages of a feldspar attackable by acids, and having the composition of labradorite, with which the jade of De Saussure was henceforth confounded, so that the name of euphotide became a synonym for a variety of diorite or hyperite. (Rose, D'Halloy, Senft)."

"Mr. Damour showed some years since that certain ornamental stones from the East, known by the name of jade, had the composition of a compact hornblende or tremolite, and a density of 2·97. This substance was however far removed alike from the jade of De Saussure and the feldspars of Delesse, and I was led, about four years since, to make an examination of authentic specimens of the euphotide of Switzerland (from the Valley of Sass, Mont Rose), which were kindly furnished by

Prof. Guyot. The results of my researches appeared in March, 1859, in a memoir upon Euphotides, in the American Journal of Science, [2], vol. xxvii, p. 336. I there showed that the jade, which forms the base of the true euphotides, possesses all the characters ascribed to it by De Saussure. It has a density of 3·33–3·38, a hardness equal to quartz, and is only attacked by acids after being heated to whiteness. This mineral is always compact, tough, with a somewhat conchoidal fracture. Its color is whitish, with shades of green, blue or red. It sometimes encloses lamellæ of a triclinic feldspar, which is attacked by acids and resembles labradorite; its presence serves to explain the error of those who have confounded this species with the true jade or saussurite of euphotide. The saussurite was also accompanied, and often penetrated, by a silvery talc, sometimes with actinolite. The smaragdite of the euphotide is a grass-green pyroxene, sometimes mixed with hornblende, and yielding, by analysis, chrome, nickel, and traces of cobalt."

"The analyses of two specimens of the jade from the euphotide of Monte Rosa (density 3·33 and 3·38) showed it to be a silicate of alumina and lime, with two or three hundredths of soda, giving for the oxygen ratios of the silica, alumina, and protoxyd, nearly 3 : 2 : 1, which are those of meionite (a species belonging to the family of the wernerites) and also of zoisite. The saussurite is however by its specific gravity, its hardness, and its chemical characters, far removed from the wernerites, and related to the family of the garnets, epidotes and zoisites. I therefore referred it to this last species, the jade of De Saussure."

"In the memoir from which the foregoing results are cited, I insisted upon the relation of isomerism, or rather of polymerism, which exists between meionite and zoisite, and I remarked that the augmentation of hardness, of density, and of chemical indifference which is seen in this last species, is doubtless to be ascribed to a more elevated equivalent, or in other words, to a more condensed molecule. These different degrees of condensation, which are constantly kept in view in the study of organic chemistry, are besides, as I have already elsewhere shown, of great importance in mineralogy, and will form the basis of a new system of classification, which will be at the same time chemical, and natural-historical. (*Comptes Rendus*, 1855, xli, 79). The different rhombohedral carbonspars, kyanite and sillimanite, hornblende and pyroxene, offer in like manner examples of different degrees of condensation, and by their chemical composition belong to series, the terms of which, like those of the hydrocarbons nC_2H_2, are both homologues and multiples of the first term. At the same time each one of these carbonates and silicates belongs to another possible series, the terms of which differ by nM_2O_2, corresponding to more or less basic salts."

"Meionite, with the ratios 3 : 2 : 1, is the most basic term known of the series of the wernerites. The proportion of silica in these minerals augments until we find in dipyre the ratios 6 : 2 : 1, with density which does not exceed 2·66. We might then expect to find a silicate which should be to dipyre, what zoisite or saussurite is to meionite, and Mr. Damour has recently had the good fortune to meet with such a mineral in a specimen of jade from China, of which he has recently given the description and the analysis (*Comptes Rendus*, May 4, 1863). This substance

closely resembles in its physical and chemical characters the saussurite or jade of Monte Rosa, of which it has the density (3·34, Damour). It is a silicate of alumina, lime and soda, and gives the same empirical chemical formula as dipyre. We may then expect to find between saussurite and this new species, to which Mr. Damour gives the name of *jadeite*, other jades having formulas which will correspond with the wernerites intermediate between meionite and dipyre. Mr. Damour has just enriched the science of mineralogy with a new species, which from the considerations above given assumes a high importance. By its hardness, its specific gravity, and its indifference to acids, jadeite is completely separated from the wernerite group, and takes its place along side of zoisite or saussurite, with the garnets, idocrase and epidotes. The following table will serve to show the relations of the new species:

Density, about	- - -	2·7	3·3
Ratio 3 : 2 : 1,	- - -	Meionite.	Saussurite.
Ratio 6 : 2 : 1,	- - -	Dipyre.	Jadeite."

To the above translation we add from the original paper of Mr. Damour, already cited, the following details. The new mineral, which is brought from China in the form of carved ornaments, has a fine green color, like that of chrysoprase, bordering on an emerald-green. It is somewhat translucent, with a scaly fracture, and a texture which is finely lamellar and occasionally somewhat fibrous. Its hardness is between that of orthoclase and that of quartz. Before the blowpipe it fuses readily into a transparent blebby glass. Its analysis by Damour gave

Silica, - - - - - - - - - - -	59·17
Alumina, - - - - - - - - - - -	22·58
Soda, and a trace of potash, - - - - - -	12·93
Lime, - - - - - - - - - - -	2·68
Magnesia, - - - - - - - - - - -	1·15
Protoxyd of iron, - - - - - - - - - -	1·56
	100·07

In his published note Mr. Damour was disposed to class this new mineral with the wernerites, but subsequently, in a private letter of the 9th July, he agrees with me in placing it near the epidotes, and adds the important observation recently made by Des Cloizeaux, that jadeite presents two axes of polarization. This species, unlike the saussurite, is not attacked by acids after fusion, a fact which is to be ascribed to the greater proportion of silica which it contains. Mr. Damour found for the specific gravity of three specimens of jadeite the numbers 3·33, 3·34 and 3·35.

Montreal, Aug. 12, 1863.

3. *Geological Survey of Canada,—Report of progress from its commencement to* 1863; illustrated by 498 wood cuts in the text, and accompanied by an atlas of maps and sections. Montreal: Dawson, Brothers, 1863.—The annual Reports of the Geological Survey of Canada have from time to time been noticed in this Journal. The large volume just now issued consists of a general review of the results thus far obtained in its various departments; in stratigraphical geology by Sir Wm. E. Logan, and his assistant Alexander Murray, in paleontology by Mr. E. Billings, and in mineralogy, lithology and chemistry by Prof. T. Sterry Hunt. As

should be expected from such a corps, every part of the volume is the result of thorough and laborious research. The volume commences with a geographical description of the country, and of its relations to the features of the continent. It then takes up the geology of Canada, and, commencing with the Laurentian system, gives full details as to the structure, distribution, etc., of the formations in order. Numerous figures and descriptions of fossils are introduced in connection with the account of the successive fossiliferous strata, making the work one of great value as an exhibition of general American geology. The Laurentian and Huronian systems, so beautifully worked out in the course of the survey, and also the Quebec group, so rich in its contributions to our knowledge of the ancient life of the globe, are described with full details and many illustrations.

At the 454th page commences the Lithological part of the volume, which occupies 220 pages. Professor Hunt here treats of the special characters of the rocks, minerals, and mineral waters, gives numerous analyses, and discusses, with many original views, the formation of minerals, rocks, and mineral veins, and also the general subject of metamorphism, which, as the volumes of this Journal have shown, his researches have done much to elucidate. Economic geology is next taken up by him, and a vast amount of information embodied in the following 160 pages, commencing with the ores of iron and other metals, and continuing with the subjects of phosphates, marls, mineral paints, peat, bitumen, plumbago, clays, building stones, &c.

The volume closes with a table of the equivalents of American and foreign rocks, a list of Lower Silurian Fossils, indicating by asterisks the formations in which the species occur, a list of Graptolites, and a number of pages of additional figures of fossils.

It is announced that the following maps will form an Atlas to be issued to accompany the volume.

1. A colored geological map of British North America, and of the adjacent parts of the United States; on a scale of 125 miles to an inch. This is reduced from a map on a scale of 25 miles to an inch; which is already engraved, and will be published separately.

2. A detailed map of the Laurentian rocks in the counties of Ottawa, Terrebonne, Argenteuil, and Two Mountains; on a scale of seven miles to an inch. This map shows the distribution of the limestone, anorthosites, and intrusive rocks of the Laurentian system, and also the outcrops of the adjacent Lower Silurian formations.

3. A detailed map of the Huronian series, along the north shore of Lake Huron, showing also the relations of the Laurentian and Silurian systems; on a scale of eight miles to an inch.

4. A detailed map of a portion of the Quebec group, from Stanbridge, C. E., to St. Albans, Vermont, showing also its relations to the Potsdam and Trenton groups; on a scale of two miles to an inch.

5. A map of the limestones of the Quebec group at Point Lévis; on a scale of a mile to three inches.

6. A map of the Superficial Geology, which will be upon the same scale as number 1.

All of these are engraved on steel or copper, and, with the exception of 5, will be printed in oil colors by chromo-lithography.

The sections, which will be about ten in number, it is proposed to give on a scale of five miles to an inch.

This Atlas will not be ready before the end of the present year.

The Canadian government has already made appropriations for the continuation of the Geological Survey another five years.

4. *Air-breathers of the Coal Period:* a descriptive account of the remains of land animals found in the coal formation of Nova Scotia, with remarks on their bearing on theories of the formation of coal and of the origin of species; by J. W. Dawson, LL.D., Principal of McGill University. With illustrations. Bailliere, New York and London, 1863. Montreal: Dawson, Brothers.—This is a highly important memoir on the Air-breathers, or terrestrial species of animals, of the Carboniferous age, found, and mostly by the author, Dr. Dawson, in the rocks of Nova Scotia. It runs through four recent numbers of the "*Canadian Naturalist*" of Montreal, and is here presented entire in a pamphlet of 82 pages, illustrated by seven plates, one of them photographic.

Dr. Dawson differs from Owen, and justly we believe, in his conclusions respecting the Archegosaurian nature of some of the species. We cite a brief abstract of the general results from pages 65–67 of the memoir.

VERTEBRATA.—Reptilia. Order Microsauria. Genus *Hylonomus*.—Reptiles or batrachians; with simple teeth in one series; biconcave vertebræ with arches anchylosed to them; ribs long and bent; limbs developed for walking; cranial bones smooth or nearly so; body protected below with oval or ovate bony scales, and above with horny scales and other appendages.

1. *Hylonomus Lyelli*, Dawson.—Teeth elongated, conical, thirty-six in each side of the jaw; larger toward the anterior part of the lower jaw; length of the lower jaw ·7 inch; limbs well developed, especially the posterior pair; bony scales oval; body above with imbricated horny scales, and rows of angular and bristly points.

2. *Hylonomus aciedentatus*, Dawson.—Teeth of maxillary and mandible thick wedge-form, or nearly round at base and flattened to an edge at top. Teeth of intermaxillaries cylindric, bluntly pointed, and with spiral furrows at the point. Number of teeth about forty on each side of jaw; length of lower jaw about 1 inch. Size more than twice that of *H. Lyelli*. Dermal covering, so far as known, similar, but the parts large in proportion.

3. *Hylonomus Wymani*, Dawson.—Teeth obtusely conical, about twenty in each side of the jaw; length of lower jaw about ·25 inch. Vertebræ elongated; size much smaller than that of *H. Lyelli*. Bony scales small and rounded, body above probably clothed in imbricated horny scales.

Order Labyrinthodontia. Genus *Baphetes*.—*Baphetes planiceps*, Owen.—Teeth conical, hooked, striated longitudinally, and with inflected and convoluted cement; in two series; the inner of larger size. Cranial bones much corrugated. Head broad; breadth in front of orbits 6 inches; length from this line to front of snout 3½ inches. Probably a dermal covering of corrugated bony scales.

Genus *Dendrerpeton*.—Batrachians with a double series of teeth; the outer simple and flattened conic, the inner conical with inflected folds of cement. Teeth also on the vomer. Bones of skull corrugated; body protected below with long ovate or rhomboid bony scales, and above with imbricated horny scales. Form elongated, fore limbs largest, tail natatory, vertebræ biconcave, neural arches and bodies ossified.

1. *Dendrerpeton Acadianum*, Owen.—Inner teeth straight conical; outer teeth short and obtuse. Length of head 2·75 inches, breadth at orbits about 2 inches, distance of orbits ·7 inch. Length one to two feet.

2. *D. Oweni*, Dawson.—Teeth slender and hooked, and cement of inner teeth more perfectly inflected. Length of skull 1·2 inch, distance of orbits about ·5 inch; length one foot or less.

Order Archegosauria. Genus *Hylerpeton*.—*Hylerpeton Dawsoni*, Owen.—Teeth simple, bluntly conical, with large pulp cavity; about 13 in one side of the jaw. Two of the anterior teeth of the upper jaw twice as large as the others, and deeply sunk in the jaw. Length of lower jaw 1·3 inch. Bones of skull puncto-striate. Limbs unknown, probably natatory.

Sedis Incertæ. Genus *Eosaurus*.—*Eosaurus Acadianus*, Marsh.—Known by two biconcave vertebræ 2·4 inches in diameter and much resembling the caudal vertebræ of *Ichthyosaurus*. See paper by Mr. O. C. Marsh, *Silliman's Journal*, vol. xxxiv.

ARTICULATA.—Myriapoda. Genus *Xylobius*.—*Xylobius Sigillariæ*, Dawson.—Body crustaceous, elongate, one to two inches in length, articulate; when recent, cylindrical or nearly so, rolling spirally. Feet small, numerous; segments 30 or more; anterior segments smooth, posterior with transverse wrinkles, giving a furrowed appearance. In some specimens, traces of a series of lateral pores or stigmata. Labrum ? quadrilateral, divided by notches or joints into three portions. Mandibles two-jointed, last joint ovate and pointed. Eyes ten or more on each side.

MOLLUSCA.—Gasteropoda. Genus *Pupa*.—*Pupa vetusta*, Dawson, Cylindrical, tapering toward the apex; surface shining, minutely marked with longitudinal ridges; whorls 8 or 9, rounded, width of each equal to half the diameter of the shell; aperture rather longer than broad; outer lip regularly rounded and somewhat reflected; pillar lip straightened above, rounded below. Edentulous or with faint ridges on columella ?. Length ·3 inch or a little more.

On the concluding page there is also the following note:

While these sheets were passing through the press, I have for the first time been enabled to study von Meyer's plates of the coal reptiles of Germany. They confirm my previous impression of the generic and probably family distinctness of *Dendrerpeton* and *Hylonomus* from *Archegosaurus*. The former of the two genera named is however that which approaches most nearly to von Meyer's genus. The arrangement of the teeth in *A. latirostris* much resembles that in *Dendrerpeton*, and the scales on the throat and belly are similar in form and arrangement. The form of the skull, and the proportions of its bones, are, however, quite different in the two genera. The vertebræ of *Dendrerpeton* are also much more perfectly ossified, its ribs very much larger and more bent,

and its limbs much larger and adapted for supporting the body on land. *Archegosaurus* must have been in all respects more ichthyoid and aquatic than any of the species of *Dendrerpeton* or *Hylonomus*.

The skull figured by von Meyer under the name of *Sclerocephalus Hauseri* may have belonged to an animal more nearly allied to *Dendrerpeton* than were the species of *Archegosaurus*.

If the animals of the type of *Archegosaurus* existed in the coal period in Nova Scotia, their remains would not be likely to occur in such repositories as the erect trunks of Sigillariæ, but only in strictly sub-aqueous deposits.

V. BOTANY AND ZOOLOGY.

1. *Origin of Varieties in Plants.*—According to the Gardeners' Chronicle, quoting from *Les Mondes*, "M. Decaisne, the very able Professor of Cultivation in the Garden of Plants, Paris, has lately brought under the notice of the Academy of Sciences some very interesting remarks upon the varieties of cultivated plants in general, and of Pears in particular." Decaisne remarks:—"The almost unlimited and ever increasing number of varieties in fruit-trees, vegetables, and all useful plants is a fact to which science has at present given too little attention. . . . These new forms, what are they? Can they be, as has been recently asserted, true species which have remained unknown up to the time when they were first subjected to cultivation; or are they merely modifications of ancient known species, assuming various appearances according to climate or situation? It may appear strange that such a question should be brought before the Academy, so natural does it seem for a species to be subject to change." . . . Botanists in the present day may be divided into two schools. The more ancient, which may be called the Linnæan, admits the changeableness of species; within certain limits, no doubt, though it is not always easy to define them. Hence those large polymorphous species, sometimes vaguely defined, but generally easy to characterize by a short descriptive phrase. The other school, which belongs especially to our own time, and which may be designated as the school of immutability, denies most positively any tendency to variation in the vegetable kingdom. According to it, the forms of species never alter in the slightest degree; and when two plants of the same genus present any palpable difference, however slight it may be, these two plants form two species, radically distinct from the beginning of things. According to M. Jordan of Lyons, a very eloquent advocate of the modern school, all the races and all the varieties admitted by the ancients become so many species. In his eyes, all our races and all our varieties of fruit-trees, of Pears amongst others, are distinct, unchangable species, always preserving their own characteristics from generation to generation. Hence it follows that these trees did not proceed, as is commonly believed, from a single or even from a few specific types, which cultivation has caused to vary, but from as many original types as there are perceptible varieties."

Although the absurdity of the latter view seems evident enough, Decaisne proceeds to refute it, by the record of his observations and experiments. He has raised seedlings from four very different varieties of

Pears, and each of the four gave rise to a considerable number of new varieties, as different from each other and from their mother, as she was from the greater part of our old varieties. "It is not only in the fruit that trees raised from the same seed differ; but also in the time of their ripening, general appearance, and in the form of their leaves. . . . Some have spines, some have none, some have slender wood, in some it is stout and coarse. Upon some of the seedlings of the old *Poire d'Angleterre* the variation went so far as to produce lobed leaves, like those of the Hawthorn or of *Pyrus Japonica*. Everything varies in the Pear-tree, even to its sap. As proof of this observe the very different success of the graft, according to the stocks employed. All the varieties and races of Pear-trees bear grafting upon a Pear-tree, that is to say, upon the wild Pear-tree; but all will not take upon the Quince, as for example the *Rance*, *Clairgeau*, *Bosc*, *Duchesse de Mars*, *&c.*" The flowers also showed very striking variations. As to size of fruit the transition is said to be perfect from the wild Pear of Blidah, which is only the size of a pea, to the *Belle d'Anguine* and *d'Amour*, which vie with a melon of middling size.

That these extreme forms belong to different species which have crossed and recrossed thousands of times with each other, producing fertile hybrids, &c., Decaisne will not allow to be probable. But it would be difficult to disprove it. He admits the crossing, but maintains that the constant fertility, after every conceivable cross, argues identity and not diversity of species.

"Does the graft, as some people maintain, alter the character of the variety?" He concludes it does not. "The notion that fruit-trees degenerate because they are propagated by grafting is an error which must be exposed. There is no single fact to prove it. Those which have been cited depend upon totally different causes, first and foremost among which are climate, unsuitable soil, and very often bad cultivation or a neglect of pruning, so common now-a-days. Our ancient pears, which a century or two ago were so justly esteemed, are now exactly the same as they ever were; they ripen at the same time and keep good just as long. . . . . The pretended degeneracy of ancient races is really nothing more than one of the clever devices of the present day."

"On the other hand, can it be true, as Van Mons and many pomologists believe, that the pips of a good fruit produce wild austere fruit, and thence return to what they suppose to be the specific type? I do not hesitate to declare the contrary, and I defy any one to bring forward an example of a good fruit, whose flowers were fertilized by their own pollen, or by that of any of their own race, whose seed has produced wild fruit. . . . It may be considered certain, that all superior varieties of the Pear-tree, and I may say of all fruit-trees, if they are fertilized by themselves, produce good fruit. They may vary, and will probably do so, sometimes in one peculiarity and sometimes in another, according to the variety; but none will become wild, any more than our seedling Cantaloupe melons return to the form and flavor of the little wild melons of India, or than our Cabbages and Cauliflowers return to some one of the wild races that grow on the sea-shore. Whatever the advocates of immutability may say, the species of plants are really subject to great variation; and there is much truth in the theory which refers to the same specific type, races and

varieties which, though very different in appearance, have the same morphological organization, and which, like the members of the same family, are capable of crossing with one another . . . Take any one of our races of Pear-trees, and transport it to all the regions of the globe; wherever it can exist, it will struggle to adapt itself to the situation, and after a few generations it will have given birth to new and numberless varieties. This fact, which takes place under our own eyes, in the case of every cultivated plant that is much distributed over the world, gives the key to those polymorphous species which perplex botanical classifiers, and which have only become what they are by nature herself having spread them over an immense expanse of country."

We remark, 1, that a view which we have more than once referred to, *i. e.* that variation is a result of domestication, and that there are no wild varieties (a view which essentially coincides with that of Jordan, as stated above), is sufficiently refuted by Decaisne's experiments. For one of the four Pears of his experiments, the *Sauger* is a wild variety, or nearly so, and its seedlings were not behind those of the other sorts in amount of variation. And 2, although no varieties may not have yet been shown to *degenerate* while duly cared for, under continued propagation from buds, it does not follow that they would *continue to exist* in perpetuity. It can hardly be otherwise than that the *existence of a species* is prolonged by sexual reproduction as it would not be by budding, or sexless propagation. A. G.

2. *Review of Mémoires et Souvenirs de Augustin Pyramus DeCandolle.*—The conductors of this Journal are rather pleased than otherwise when articles are reprinted from its pages. Nor can they at all object to abridgments of such articles, when the omissions are indicated in the customary manner. But in this respect they have somewhat to object to in the reprint, from our January number, of the article above-mentioned, abstracted in Dr. Seemann's Journal of Botany, without anything to mark the *lacunæ*. This, however would not be worth notice, except for the statement that the article is thus reproduced "with corrections by the author." This seems to imply an agency in the matter on the author's part, which surely it could not have been intended to assert. It may, therefore, well enough be stated, that the corrections in the author's copies sent to the Editor of the Journal of Botany, as to other correspondents, amounted, we believe, only to the change of a single letter in a misprinted word. So that there is some mistake or inadvertance in the matter, which we are not able to explain. A. G.

3. *On Welwitschia, a new genus of Gnetaceæ*, by Joseph Hooker, M.D., F.R.S., etc. pp. 48, tab. 14.—This is a separate issue, in folio form, of a memoir in the current (24th) volume of the Transactions of the Linnæan Society, illustrated by fourteen superb and elaborate plates, the expense of which has been mainly defrayed by the Royal Society, from a parliamentary fund placed at its disposal for the promotion of scientific research. By the coöperation of these two learned societies, the fruits of Dr. Hooker's admirable researches are given to the scientific world in a form and manner worthy of them and of the wonderful subject. Dr. Welwitsch's discovery of this strange plant, and what was then known of it, are briefly adverted to in this Journal, vol. xxxii, p. 289, two years

ago. The present memoir was published in the spring of the present year, and has been duly noticed in the principal scientific journals. It accidentally happened that the copies addressed by the author to his correspondents in the United States were only recently received. Though late, some notice of the plant and of Dr. Hooker's investigations will still be welcome, no doubt, especially to many readers who may never see the memoir itself.

A good idea of the vegetable wonder in question is given in the following brief account of its appearance and prominent characters, drawn partly from the descriptions of its discoverer, and partly from specimens sent to England :

"The *Welwitschia* is a woody plant, said to attain a century in duration, with an obconic trunk about two feet long, of which a few inches rise above the the soil, presenting the appearance of a flat, two-lobed, depressed mass, sometimes (according to Dr. Welwitsch) attaining 14 feet in circumference (!), and looking like a round table. When full grown it is dark brown, hard, and cracked over the whole surface (much like the burnt crust of a loaf of bread); the lower portion forms a stout tap-root, buried in the soil, and branching downward at the end. From deep grooves in the circumference of the depressed mass two enormous leaves are given off, each six feet long when full-grown, one corresponding to each lobe; these are quite flat, linear, very leathery, and are split to the base into innumerable thongs that lie curling upon the surface of the soil. Its discoverer describes these same two leaves as being present from the earliest condition of the plant, and assures me that they are in fact developed from the two cotyledons of the seed, and are persistent, being replaced by no others. From the circumference of the tabular mass, above, but close to the insertion of the leaves, spring stout, dichotomously branched cymes, nearly a foot high, bearing small erect scarlet cones, which eventually become oblong, and attain the size of those of the common spruce fir. The scales of the cones are very closely imbricated, and contain, when young and still very small, solitary flowers, which in some cones are hermaphrodite (structurally but not functionally), in others female. The hermaphrodite flower consists of a perianth of four pieces, six monadelphous stamens, with globose trilocular anthers, surrounding a central ovule, the integument of which is produced into a styliform sigmoid tube, terminated by a discoid apex. The female flower consists of a solitary erect ovule, contained in a compressed utricular perianth. The mature cone is tetragonous, and contains a broadly winged fruit in each scale. Its discoverer observes that the whole plant exudes a resin, and that it is called *Tumbo* by the natives, —whence he suggests that it may bear the generic name of *Tumboa*; but this he withdrew at my suggestion, for reasons which I shall presently give. It inhabits the elevated sandy plateau near Cape Negro (lat. 15° 40′ S.) on the S. W. coast of Africa."

Welwitschia mirabilis, Hook. fil. was also detected and made known—indeed the first actual materials, with a drawing of the plant, were sent to England—by Mr. Baines from the Damara country, in lat. 24° or 25° S. about 500 miles south of Cape Negro. Mr. Baines is an artist, and his original colored sketch of a plant in fruit is reproduced on the first plate of the memoir. It appears as if five-leaved; but probably one of the two original leaves is split into two, the other into three segments. As might be inferred from the form and structure, the *Welwitschia* inhabits a dry region. Mr. Monteiro writes to Dr. Hooker :—

"— about thirty miles distant from the coast, I passed a plain about three

miles across, on which this plant was growing abundantly; that is to say, I saw about thirty specimens on my line of march. The plain was perfectly dry, and bare of other vegetation than the *Welwitschia* and a little short grass. The ground was a hard quartzose schist. The *Welwitschia* was generally growing near the little ruts worn in the plain by running water during the rainy season."

And from Damara Land, Mr. Anderson writes that,—

"Rain rarely or never falls where this plant exists. [Yet the night dews are heavy, as other authorities mention.] I have crossed and recrossed Damara Land throughout its entire length and breadth, but only found the plant growing on that desperately arid flat, stretching far and wide about Walvisch Bay."

We are familiar with plants of very diverse orders of Dicotyledons and Monocotyledons which are adapted to arid regions by great restriction of surface. Here a similar plan is adopted by a Gymnosperm; for the resemblance to *Coniferæ* and *Casuarineæ* indicated by Dr. Welwitsch is shown by Dr. Hooker to import a close affinity, the author referring the plant to *Gnetaceæ* near to *Ephedra*. Its permanently abbreviated ascending axis—of which the greater part consists of the first internode, below the cotyledons,—increases in thickness but hardly in length, developes no other than the seminal pair of leaves, above which the disciform bilobate axile portion or "crown," gradually produced, bears year by year only leafless inflorescence.

Hæmanthus equally bears a pair of leaves; but these die off as the season of drought advances, when the plant is reduced to a minimum of surface in its spherical bulb,—which outspreads a new pair of leaves when the rainy season returns. But in *Welwitschia* the two leaves are permanent. Wherefore they are firm and coriaceous, and, increasing by basal growth from year to year, the older parts doubtless become inactive at length, while fresh surface below is annually renewed, under the shelter (as Dr. Hooker describes) afforded by the deep grooves which in old plants separate the growth of the hypocotyledonary stock from that of the crown above, and is filled by the tender growing bases of the leaves.

Having given a detailed generic character of *Welwitschia*, and a comparative view of the Gnetaceous genera, now three in number, Dr. Hooker proceeds to describe at length the trunk, leaves, inflorescence, flowers, fertilization, embryogeny and seed of this curious subject,—comparing it in the latter respects with *Coniferæ* and *Cycadaceæ* on the one hand, and with *Santalum* and *Loranthus* on the other, and closing with a general summary of the results.

An abstract or analysis of this most important paper is beyond our present reach or space. But we may refer to some of the special points.

The most obvious peculiarity of *Welwitschia* is, that "it appears to be the only perennial flowering plant which at no period has other vegetative organs than those proper to the embryo itself,—the main axis being represented by the radicle, which becomes a gigantic caulicle, and developes a root from its base and inflorescences from its plumulary end, and the leaves being the two cotyledons in a very highly developed and specialized condition." It is an excellent case, accordingly, if any such were still needed—for showing the nature of the radicle as stem, or ascending axis (not root,)—a view which we supposed observation had long ago demonstrated. Dr. Hooker, in a note, refers to this view as

expressed by Adr. Jussieu in his *Cours Elémentaire* (which appeared in 1843 and 1844), and in Gray's Introduction to Botany (*Bot. Text Book*), 1858. But the same view is taken in all the earlier editions of the latter work; even in the first (1842) the radicle is spoken of as the first internode of the stem (p. 29, note); and probably the idea will be found distinctly expressed in works of an earlier date. Dr. Hooker, in the note referred to, assents to the proposition that "the radicle is rightly regarded as an axis" i. e. an ascending axis, "and not a root," but does not agree that it is an internode. To us, the one implies the other. Conceiving, as we do, the fundamental idea of the morphology of the phænogamous plant to be, that the ascending axis consists of a series of superposed internodes, each crowned by a leaf-bearing point or ring (the node), the first internode must needs be that which is crowned by the first leaf or pair of leaves, the cotyledons; and its whole developement confirms this view.

Dr. Hooker notes the curious fact that in *Welwitschia* flower buds are occasionally produced on the stock below the insertion of the leaves, that is, on the radicle or caulicle itself; and Dr. Masters pointed out to him analogous cases of shoots thus originating, one of which was described by Bernhardi thirty years ago. It is simply the case of adventitious buds; these might seem as likely to occur on the first internode as on any later one.

Welwitschia, having a dicotyledonous embryo, has also essentially an exogenous stem, i. e. "the vascular system is referable to the exogenous plan, but its arrangement into concentric wood wedges is very rude." But the superadded isolated and closed vascular bundles of the stock and root, and especially their losing themselves in the periphery of the stock, are endogenous analogies. So also is the strictly parallel and free venation of the leaves; yet, as there are no cross veinlets, thus favoring the splitting up of the leaf into laciniæ, this looks as much or more towards *Cycadaceæ* and broad-leaved *Coniferæ*.

The total absence of anastomosing veinlets in the leaf, each nerve representing a single and independent vascular axis, extending, in *Welwitschia*, from the axis of the trunk to the apex of the leaf, causes such leaves as these and those of *Dammara*, &c., to "resemble more closely a series of parallel uninerved leaves united by cellular tissue, than a foliar expansion of parenchyma traversed by one system of inosculating vessels, and the frequent presence of many linear cotyledons in these plants seems to favor this view, as does the mixed character of the foliage of *Podocarpus*, of which some species have uninerved and others many-nerved leaves. The numerous flower-buds along the periphery of the crown also further favor this view." That is, in *Welwitschia*, where this ingenious surmise carries a plausibility, which it does not when applied to *Podocarpus*.

The binary symmetry of *Welwitschia*, beginning with the cotyledons, is carried through the inflorescence up to the decussating pairs of bracts of the cone and the two leaflets in each whorl of the hermaphrodite perianth. But the stamens are six, at first sight a monocotyledonous analogy; yet they may be regarded three sets of two, notwithstanding their monadelphy. The flowers are diœcio-polygamous, i. e., of two sorts, one

female, the other structurally hermaphrodite, but the gynæcium sterile, though well-developed, except that no embryo-sac appears. The hermaphrodite cones and their flowers accord in many respects strikingly with the male cones of *Ephedra;* but the anthers are trilocular, which is remarkable. The simple ellipsoidal pollen is the same in both. In *Ephedra* the stamens vary from two to eight, and the column is solid, there being no rudiment of a gynæcium.

The female fruitful cones are about three inches long, and bright red when fresh.

The integument of the ovule, as in *Gnetum*, is prolonged at the summit into a style-like body, thus closely simulating a pistil; and the apex of this styliform tube, which is thin and merely erose in the fertile flower, in the structurally hermaphrodite flower is dilated into a broad papillose disk, exactly imitating a highly developed stigma—a marked instance of a highly developed organ which is functionless; for no pollen has been detected upon it, and no embryo-sac in the nucleus. Here Dr. Hooker speculates upon "the possibility of *Welwitschia* being the only known representative of an existing or extinct race of plants, in which such a stigma-like organ was really capable of performing the function of a stigma. And, when we see this organ occurring in a hermaphrodite flower, it is easy to suppose that we have in *Welwitschia* a transition in function, as well as in structure, between the gymnospermous and angiospermous Dicotyledons; and that the ideal race consisted of hermaphrodite plants, in which the office of the stigma of the carpellary leaf was performed by a stigmatic dilatation of the ovular coat itself."

This assumes that the gymnospermous theory established by Brown is correct (whatever be the nature of the cone-scales, rameal or carpellary, simple or compound), and applicable to the Gnetaceous as well as to the Coniferous type. This view, lately much questioned, Dr. Hooker maintains, and enforces, as respects *Gnetaceæ*, by very convincing and in part wholly original arguments, drawn from his own researches upon the present plant and its allies. We refer to pp. 28 to 31, which we could not readily condense, and have not room to copy. The same is to be said in regard to the resemblances or analogies in gynæcial structure between *Gnetaceæ* and *Loranthaceæ*, &c.—a subject upon which we await expectantly Prof. Oliver's investigations. Moreover, as Dr. Hooker remarks upon another page, the decisive or final comparative view of the structures in question cannot be had until the homology of the ovule itself is settled. In cases where the flower is so simplified that the nucleus of an ovule directly terminates the floriferous axis, and is surrounded by few and simple, or peculiarly specialized, investments, the discrimination of these must be difficult enough, and must ultimately depend upon the theory adopted as to the nature of the ovular coats. If these be regarded as foliar (as a rigid application of adopted morphological principles will require), then a complete transition from gymnospermy to angiospermy is probable, and may be expected to be demonstrable.

The fertilization and embryology of *Welwitschia* have been wonderfully worked out, considering the materials, by Dr. Hooker, and the two most elaborate and valuable plates of the memoir are filled with the details. Suffice it to say, that it appears that the pollen must be brought

by insects to the ovule of the female flowers, at an early period, before the nucleus is covered by the ovular coat or by the perianth, and before the former has produced its styliform apex, down which it would be nearly impossible to convey the grains of pollen which were bodily found on the nucleus, with their tubes there produced. So that, notwithstanding the carpel-like form of the ovule, the impregnation is absolutely gymnospermous. As to embryo-formation also, "there is a general agreement in many most essential particulars with *Cycadaceæ* and *Coniferæ*," especially, and beyond what has already been adverted to, in "the free embryo-sac being filled with endosperm-cells previous to fertilization, the numerous secondary embryo-sacs, the position of the germinal vesicle at the base of these sacs, and in the high development of the long tortuous suspensor." There is an agreement with Angiosperms, however, in several particulars, especially in that of "the germinal vesicle giving rise to one embryo only." And it is concluded that, in special reference to *Santalum* and *Loranthus*, "*Welwitschia* presents an embryogenic process intermediate between that of Gymnosperms and Angiosperms."

And here we should not omit to mention that its wood differs from that of all known Gymnosperms in wanting the disc-bearing wood-cells!

It will be conceded that *Welwitschia* is "the most wonderful discovery, in a botanical point of view, that has been brought to light during the present century." Also, that Dr. Hooker has enjoyed (and improved) an opportunity unequalled by any botanist since that which placed the *Rafflesia* in Mr. Brown's hands. A. G.

4. *American Tea-Plant.*—A newspaper announcement states that the Tea Plant has been discovered by a Chinaman (or as some say by an Englishman formerly engaged in the tea-culture in Assam), in the United States, "covering a large area of land in the central counties of Pennsylvania," and that tea of excellent quality and various sorts, green and black, has been made for the market by a company organized for the purpose. We are told that the agent of the company exhibits in this connexion, a drawing which is recognized as representing a genuine Tea-plant.

A specimen of the prepared tea has been shown to us; by which we recognize that this American Tea-plant is the well-known *Ceanothus Americanus*, the *New Jersey Tea*, the leaves of which were used for this purpose at the beginning of the American revolution. Some one has remarked that the substituted beverage must have tried the patriotism of our great-grandmothers; but others report more favorably of its qualities.

A. G.

5. *The Compass Plant.*—Riding near Chicago, August 8, 1863, I saw, for the first time, *Silphium laciniatum* growing wild. The field had once been ploughed and sown with timothy, and there was a grove a few rods to the east. Notwithstanding these unfavorable circumstances, I took a rough measurement of thirty plants, without selection, as follows: Holding a card over each plant with its edge parallel to the central line of my own shadow, I marked upon the card a short line parallel to each leaf of the plant. Measuring afterward the angle which each mark made with the edge of the card, and subtracting from each angle the azimuth of the sun for the estimated central time of observation, I obtained the following results. Only one plant, bearing four old leaves, gave an average

angle with the meridian of more than 34°. Their mean was 18° west. The remaining 29 bore 91 leaves; which made with the meridian the following angles, viz: Seven made angles greater than 35°; fifteen, angles between 35° and 20°; sixteen, angles between 20° and 8°; twenty-eight, angles between 8° and 1°; and twenty-five, angles less than 1°.

Of the 69 angles less than 20° the mean is N. 33′ E., i. e. about half a degree east of the meridian. The error of azimuth, from my want of means to determine the time accurately, may have been as much as three times this quantity. One half the leaves bear within about half a point of north, two-thirds within a point.

The magnetic declination was about 6° east. The observations were made when the sun was about on the magnetic meridian. T. Hill.

Cambridge, Mass., Sept. 6, 1863.

Zoology.—

6. *Classification of animals based on the principle of Cephalization;* by J. D. Dana.—A modification of the brief section on the elliptic method of decephalization, at page 327, is suggested in a note on page 352. The subject admits of much fuller elucidation, and the following is here presented as a substitute for the section referred to.

9. *Elliptic.*—Exhibited in the defectiveness or absence of segments or members normally pertaining to the type of the order or class containing the species, and arising from *abnormal weakness* in the general system, or in an organ. It is exhibited especially in the degradational or inferior types. The cases are—

Incomplete or deficient (1) segments, or (2) members, in either (*a*) the *anterior*, or (*b*) the *posterior* portion of the body; as in the absence of some, or all, of the teeth in Edentates; of the posterior limbs in Whales; of the abnormal appendages and posterior thoracic segments in some Schizopods or degradational Macrurans; of the antennæ, either one or both pairs, in many inferior Entomostracans; of wings in the Flea, etc.

This method of decephalization differs from the defunctionative in implying a deficiency not only of function but also of organ or member.

The incompleteness or deficiency of normal parts referred to above will be better appreciated if contrasted with deficiencies from other causes. The principal other causes are the following:

(1.) A *high degree* of cephalization or cephalic concentration in the system.—Thus in the Crab, the highest of Crustaceans, the abdomen is very small, and *elliptic* both in segments and members, because of the *high degree* of cephalic concentration; while in the Schizopods referred to above, and in the Limulus and many other inferior Crustaceans, the same deficiency comes from *weakness* of life-system or decephalization.

(2.) High development of one part of an organ, at the expense of other adjoining parts.—This principle may be said to include the preceding, since, in that, there is a high development of the anterior or cephalic portion of the structure at the expense of the posterior or circumferential. But here, there is reference to special organs rather than to the structure as a whole. Thus, in the foot of a Horse, there is an enlargement of one toe, normally the third, at the expense of the others, and this enlarged toe has the full normal strength that belongs to the foot under the Herbivore-type.

It is apparent from the facts in paragraphs (1) and (2), that there may

be an *elliptic* method of *cephalization* as well as of *decephalization*. The Crab-type is a striking example of the former. The foot of the Horse, considering separately the *Horse-type*, is a case under the former rather than the latter; for, in any related species, a lessening of the disparity of the toes would be evidence of weakness and inferiority *under that type*. Yet, as compared with the higher Carnivore-type, in which the life-system has the strength to develop all the toes in their completeness and fulness of vigor, with great strength of foot, the foot of the horse is *elliptic*, and a mark of inferior cephalization. In the typical Ruminants, the complete series of teeth is indicated in an embryonic state before birth; but part of them fail of development, while the others—those specially characteristic of the type—go forward to great size and perfection. As in the foot of the Horse, there is here an enlargement of one portion at the expense of the others. And this, under the Ruminant-type, is progress toward the highest condition of the type, or *cephalization* by an elliptic method. A Ruminant in which the teeth should be all equally developed would be one of too great feebleness of system to carry the structure to its typical perfection; and such is the Eocene Anoplothere.[1] If, however, the Ruminants were referred to the Megasthene-type as represented in the Carnivores, the *deficiency* of teeth would be an example of *decephalization* by the elliptic method; for such a deficiency under the higher type of the Carnivores would be evidence of abnormal weakness.

The same principle is exemplified in Carnivores; for the size and number of the molar teeth are less the larger the canines. The Machærodus with its huge tusks and but *three* molars to either side of a jaw is a remarkable example. Again, in the Elephant, two incisors are developed into the great tusks of the upper jaw at the expense of the other incisors and canines; and jaws that look as if bearing profoundly the mark of degradation or decephalization, are hence compatible with high *cephalization* under the Herbivore-type.

It is not to be inferred that the enlargement of one part of an organ at the expense of others, is *necessarily* an indication of *general* elevation of grade. Even in the case of the foot of the Horse, the elevation implied is elevation only under the Horse-type or among Solidungulates, and not elevation above all other Herbivores.

These examples are sufficient to illustrate the contrast between the elliptic method of cephalization and of decephalization; and also the fact, that a case of the former in one relation may be one of the latter in a higher, that is, if referred to a higher group as the standard type. The cases that would come under the elliptic method of *cephalization* (as that of the Crab) have been already referred by the writer to the *concentrative*, they being a result of concentration in the life-system.

[1] "Amongst the varied forms of existing Herbivora we find certain teeth disproportionately developed, sometimes to a monstrous size; whilst other teeth are reduced to rudimental minuteness, or are wanting altogether: but the number of teeth never exceeds, in any hoofed quadruped, that displayed in the dental formula of the Anoplotherium. It is likewise most interesting to find that those species with a comparatively defective dentition, as the horned Ruminants for example, manifest transitorily, in the embryo-state, the germs of upper incisors and canines, which disappear before birth, but which were retained and functionally developed in the cloven-footed Anoplothere."—*Goodsir, British Assoc. Rep.*, 1838. *Owen's Brit. Mamm.*, 1846, 433.

(3.) That simplicity of structure which is opposed to the specialized or differentiated condition of superiority of type.—It is evident that the examples of elliptic decephalization, taking this term in its most comprehensive sense, may include the various simplifications which mark unspecialized structures of inferior types. Yet we propose to restrict the term to those examples of deficiencies which are obviously connected with degradational or hypotypic conditions under any type.

7. *On the Embryology of Astercanthion berylinus* Ag, *and a species allied to A. rubens M. T. Asteracanthion pallidus* Ag.; by A. AGASSIZ. 8 pp. 8vo., from the Proceedings of the American Academy of Arts and Sciences, Ap. 14, 1863.—This paper is a brief description of the embryology of the Echinoderm, above mentioned, illustrated by two excellent plates. The results, it states, are to appear in full in the fifth volume of Prof. Agassiz's Contributions to the Natural History of the United States.

8. *List of the Echinoderms sent to different Institutions in exchange for other specimens with Annotations;* by A. AGASSIZ. pp. 17–28, 8vo.—The annotations in this printed Catalogue are observations on characteristics of the species, or localities, references to authorities, &c.

9. *On synthetic types in Insects;* by A. S. PACKARD, Jr. (from the Jour. Bost. Soc. Nat. Hist., June, 1863, pp. 590–603).—Mr. Packard has here brought together much information and some new suggestions with regard to the analogies between the different tribes of Insects. We shall take occasion to quote from his memoir in another number of this Journal.

10. *Beiträge zur Kenntniss der fosillen Pferde und zu einer vergleichenden Odontographie der Hufthiere im Allgemeinen;* von Prof. L. RÜTIMEYER. 144 pp. 8vo, with 4 plates. Basel, 1863. (From the Verhandlungen der naturf. Ges. in Basel, vol. iii, Heft 4, 1863).—Prof. Rütimeyer, of Basel, the author of a valuable work on the ancient *Lake habitations* of Switzerland,[1] takes up in this new memoir, the subject of fossil horses and related Ungulates. His able memoir is illustrated by numerous figures, representing fossil and recent teeth of different genera and species of Horse, and also of other hoofed quadrupeds.

11. *Methods of Study in Natural History;* by L. AGASSIZ. 320 pp. 12mo. Boston, 1863: Ticknor & Fields.—The chapters of this interesting volume were originally delivered as oral lectures by Prof. Agassiz, and subsequently, with the exception of the last, written out in a popular form for the Atlantic Monthly. The author here presents his views on nomenclature and classification, on the nature and constancy of species as opposed to the transmutation theory, on the formation of coral reefs and the length of geological time as determined by their rate of progress, on alternate generation, and on the ovarian egg and the relations of embryology to classification.

12. *On the nomenclature of the Foraminifera;* by W. K. PARKER and T. R. JONES. Part VIII, *Textularia.* 8 pp. 8vo. (Ann. and Mag. Nat. Hist. for Feb. 1863).—The characteristics, varieties of form, geographical distribution and generic synonymy of the Textularia group are the subjects of this paper.

[1] Die Fauna der Pfahlbauten in der Schweiz. Untersuchungen über die Geschichte der wilden und der Haus-Säugethiere von Mittel-Europa. 248 pp. 4to, with woodcuts and 6 plates. Basel, 1861.

VI. ASTRONOMY AND METEOROLOGY.

1. *Discovery of a new Planet, Asteroid* (79), (in a letter to the Editors from Prof. JAMES C. WATSON, Director of the Observatory, dated Ann Arbor, Oct. 9, 1863).—I have the pleasure to inform you that I discovered a new planet on the night of the 14th of September, which I have observed as follows:

Ann Arbor M. T.	R. A.	Dec.
1863 Sept. 14d 15h 22m 56s	1h 0m 45·54	+9° 53′ 36″·2
" 14 16 24 21	1 0 44 52	9 58 24 ·1
" 15 10 0 49	1 0 23·99	9 49 16 ·8
" 16 9 42 43	0 59 54·76	9 44 0 ·0
" 16 9 48 28	0 59 54·33	9 43 54 ·5
" 19 9 8 11	0 58 16·68	9 26 13 ·4
" 19 9 45 37	0 58 15·56	9 26 4 ·0
" 20 14 45 1	0 57 32·34	9 18 21 ·0
" 21 9 46 18	0 57 3·99	9 13 7 ·6
" 22 9 48 36	0 56 25·42	9 6 14 ·1
" 23 10 59 50	0 55 44·27	+8 58 54 ·5

I have also observed the planet on Sept. 25, 26, 28 and 29, and on Oct. 6, but the observations are not yet reduced.

From the observations on Sept. 14, 19 and 23, I have computed the following elements, which up to the present time represent the observed places very satisfactorily:

Elements of Asteroid (79).

Epoch. 1863, Sept. 19·0, M. T. Greenwich.

$$M = 333^\circ\ 50'\ 17''\cdot8$$
$$\pi = 45\ 35\ 56\ \cdot0 \left.\right\} \text{Mean Equinox 1863·0.}$$
$$\Omega = 206\ 37\ 17\ \cdot4 \left.\right\}$$
$$i = 4\ 38\ 27\ \cdot1$$
$$\varphi = 11\ 19\ 25\ \cdot1$$
$$\log. a = 0{\cdot}388320$$
$$\log. \mu = 2{\cdot}967527$$
$$\mu = 927''\cdot955$$

These elements give the following ephemeris for Greenwich mean noon:

	R. A.	Dec.	log. Δ.
Oct. 25	0h 33m 15s	+4° 39′·9	0·01742
26	0 32 43	4 32 ·4	0·01889
27	0 32 13	4 25 ·1	0·02044
28	0 31 44	4 18 ·0	0·02206
29	0 31 17	4 11 ·1	0·02371
30	0 30 51	4 4 ·3	0·02539
31	0 30 27	3 57 ·8	0·02716
Nov. 1	0 30 5	3 51 ·6	0·02898
2	0 29 45	3 45 ·6	0·03085
3	0 29 27	3 39 ·7	0·03276
4	0 29 11	3 34 ·2	0·03471
5	0 28 56	3 28 ·8	0·03668
6	0 28 44	3 23 ·7	0·03870
7	0 28 34	3 18 ·9	0·04073
8	0 28 27	3 14 ·3	0·04277
9	0 28 22	3 10 ·0	0·04481
10	0 28 20	+3 5 ·9	0·04686

The expressions for the coördinates referred to the equator are the following:

$$x = r(9{\cdot}999712)\sin(135^\circ\ 31'\ 25''{\cdot}0 + v)$$
$$y = r(9\ 974897)\sin(\ 44\ \ 47\ \ 45\ \ {\cdot}5 + v)$$
$$z = r(9{\cdot}521645)\sin(\ 51\ \ 25\ \ 55\ \ {\cdot}8 + v)$$

The planet shines like a star of the 10th magnitude.

2. *Observations in Brussels of the Meteors of August*, 1863; by Mr. Quetelet.—Mr. Quetelet, on the evening of Aug. 7th, saw nine shooting stars between $10^h\ 10^m$ and $11^h\ 10^m$. On the 8th in about an hour from $10^h\ 6^m$ he saw 17. On the 10th, observing alone as before, from 9^h to 10^h he saw 23, and from 10^h to 11^h, 33 meteors. He registered upon a chart the paths, and could not command more than one-third of the sky. He estimated the numbers visible for the two hours at 70 and 100. From 11^h to 12^h his son and Mr. Hooreman saw 112 and estimated the number visible at 180. On the 11th Mr. Quetelet saw 11 between $10\frac{1}{2}^h$ and 11^h, and his son and Mr. Hooreman saw 40 during the next hour.

3. *Observations by* Mr. Alex. S. Herschel *of the August Meteors, in England.*—Mr. Alex. S. Herschel, son of Sir John Herschel, in a letter to Mr. Quetelet, published in the *Bulletin* of the Royal Belgian Academy, gives the following altitudes and velocities of five meteors of the August stream observed on the evening of Aug. 10th, 1863. The second column of the table below gives the hour of observation, the third the duration of flight in seconds, the fourth the altitude at first appearance, the fifth the altitude at disappearance, and the sixth the velocity. The unit of altitude and velocity is the English mile.

Altitudes and velocities of shooting stars observed Aug. 10th, 1863, in England.

No.	Time.	Duration.	1st Alt.	2d Alt.	Velocity.
1.	$9^h\ 23^m$	3^s	70	58	35
2.	$36\frac{1}{2}^m$	$1^s{\cdot}7$	114	73	36
3.	$10^h\ 7\frac{1}{2}^m$	$1^s{\cdot}2$	131	66	75
4.	11^m	$1^s{\cdot}4$	105	52	41
5.	19^m		72	58	38

The altitude and velocity of No. 3 Mr. Herschel considers as too great. The path and duration of No. 5 were very carefully noted, and he thinks the velocity of 38 miles is very near the truth. Two flights, No. 1, and No. 4, were observed at three places.

These velocities imply a less inclination of the August ring (motion retrograde) than that given in this Journal, 2d ser., vol. xxxii, p. 448.

Mr. Herschel gives also the altitudes of four other meteors as follows:

Aug.	8th,	$10^h\ 58^m$	1st alt.	153 miles,	2d alt.	61 miles.
"	9th,	$12^h\ 5^m$	"	"	"	45 "
"	10th,	$10^h\ 1^m$	"	52 "	"	25 "
"	11th,	$12^h\ 10\frac{1}{4}^m$	"	122 "	"	86 "

The second and fourth were brilliant fireballs from which explosions were heard.

4. *Observations on the August Meteors, by* Dr. E. Heis, *at Münster.*—At Münster this year, the following numbers were seen, from Aug. 8th to Aug. 14th, by Prof. E. Heis and eighteen assistants. Most of the paths were drawn on charts.

Number of shooting stars seen at Münster from Aug. 8th to Aug. 14th, 1863.

Hour.	8th.	9th.	10th.	11th.	12th.	13th.	14th.	Total.
From 9^h to 10^h,	26	41	93	24	45	33	18	280
10^h to 11^h,	67	57	144	90	54	44	29	485
11^h to 12^h,	58	61	166	98	69	44		496
12^h to 13^h,			158					158
13^h to $13\frac{1}{4}^h$,			39					39
Total,	151	159	600	212	168	121	47	1458
Per hour from 9^h to 12^h,	50	53	134	71	56	40		

From 9^h to 10^h on the 11th the sky was mostly covered by clouds. The observations were made entirely in the open air. The heavens were divided among the several observers. Each observer drew on the chart the path, and a secretary noted the time (to the second), the magnitude, and other circumstances. On the 10th the stars followed each other so fast that the smaller ones, of the third and fourth magnitudes, could not be recorded. No star was counted twice.

The brightness and duration of the trains of the meteors on the 10th were remarkable. With the naked eye trains were noticed which lasted 7, 10, 14 and even 43 seconds. With the comet seeker one train was seen 55, another 60, and a third 168 seconds.

Corresponding observations were made at places near Münster, which will furnish the data for computing altitudes.—Condensed from *Heis' Wochenschrift of Aug. 19th and Aug. 26th.*

5. *Die grosse Feuerkugel, welche am Abende des 4. März, 1863, in Holland, Deutschland, Belgien und England geschen worden ist*, von Dr. Eduard Heis. Nebst einer Karte. 8°, pp. 56. Halle, 1863. Abdnuck aus der Wochenschrift, &c.—This is a very full account of a detonating meteoric fireball which was visible throughout a region 500 miles in diameter. Dr. Heis obtained reports from over 100 different places, and his summary of the various accounts is well arranged. The meteor was first seen at an altitude of 88 English miles over the North sea, and it disappeared with a loud explosion over the south part of Holland at an altitude of 17 miles. The course was nearly south, was inclined 22° to the horizon, and was 187 miles long. The duration of flight was estimated at 4 or 5 seconds. The velocity was considered therefore as $41\frac{1}{2}$ miles, which gives a hyperbolic orbit around the sun for its former path.

6. *Die Meteoriten, ihre Geschichte, mineralogische und chemische Beschaffenheit*, von Dr. Otto Buchner. 8vo. pp. 202. Leipzig, 1863.—This work attempts to give a brief historical sketch of all described meteorites, including what is known regarding their mineralogical and chemical characters, and also indicates in what museums or collections the specimens are preserved. It is divided into four sections. Part I treats of *Stony Meteorites*, whose time of fall is known; these number 153 and are arranged chronologically, commencing with the *Ensisheim* stone, which fell Nov. 16th, 1492, and ending with that of *Meno*, whose fall was observed Oct. 7th, 1862. II. *Stony Meteorites*—time of fall unknown—nine in number, arranged in the order of their discovery. III. Including those intermediate in character between the stony and iron meteorites, or the *stone-and-iron* meteorites. These number 10, and are arranged in the order of their discovery. IV. *Iron Meteorites*, eighty-three in number,

arranged in the order of their discovery. The date of fall of only two of these is with certainty known, viz: *Agram*, May 26th, 1751, and *Braunau*, July 14th, 1847. It may be questioned whether the iron from Charlotte, Dickson Co., Tenn., fell as stated on July 31st (or Aug. 1st), 1835, as the evidence is far from conclusive that the mass of iron found had any connection with the meteoric explosion which took place at that time.

The four classes make in all a sum total of 255 meteorites. Of these we notice over 60 are from the United States, among them are perhaps included a few that when more thoroughly investigated will prove to have no claim to meteoric origin.

The book also contains a catalogue of the various European and American collections of meteorites, and the number of localities represented in each cabinet. Among the public collections containing specimens from more than 50 localities are the museums of Vienna (194), London (British Museum, 190), Göttingen (125), Paris (Garden of Plants, 53). The largest private collections are those of R. P. Greg, Manchester, Eng., numbering 191—Reichenbach, Vienna, 176—C. U. Shepard, Amherst College, 151—Nevill, London, 101—Auerbach, Moscow, 76—Neumann, Prague, 61—J. Lawrence Smith, Louisville, 60.

This work is exceedingly valuable to all who are occupied in the study of meteorites. In most cases it gives accurate references to original authorities, and full citations of the literature of the subject. We have noticed some minor errors in the statements made, but it is almost impossible to bring together such a mass of material without committing an occasional oversight. The author deserves the thanks of all interested in the subject for arranging in such a compact and convenient form the facts which heretofore were only to be found by a laborious search through hundreds of volumes of Journals and Proceedings of learned Societies. Dr. Buchner proposes, as time shall demand, to publish a Supplement to this book, and begs that those interested will communicate to him information regarding private or public meteoric cabinets, and corrections or omissions noticed in the present work. His address is, Dr. Otto Buchner, Professor in the University of Giessen, Darmstadt. G. J. B.

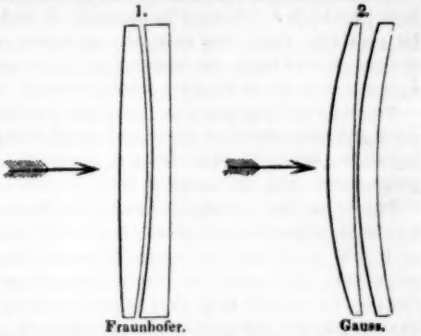
7. *Shooting Stars of November.*—The Committee of the Conn. Acad. of Arts and Sciences on Periodical Meteors have arranged for a watch on the nights and mornings near the 13th of the coming November. A special watch for determining parallax will be kept (weather permitting) on the night of the 13th and morning of the 14th. The Committee, in like manner as heretofore, invite observers in other places to communicate their observations. They may be sent either to Prof. H. A. Newton or to the undersigned. Alex. C. Twining, *Ch'n.*

New Haven, Oct. 27th, 1863.

VII. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *New Achromatic Object-glass.*—A new combination of curves has recently been applied by Steinheil of Munich, in the construction of the achromatic object-glass. It was originally proposed by Gauss above forty years ago, in a communication to the "*Zeitschrift für Astronomie*," vol. iv, 1817. The curves are characterized by their great depth and abruptness, having

in some cases radii of less than *one-tenth* of the focal length. Each lens is a meniscus, whereas the practice has hitherto been to make both the surfaces of the crown lens convex, with more or less variation in the proportion of curvature, always, however, retaining the same general character of convexity. The lenses of the new system are shown in the following figures in comparison with the Fraunhofer lens.



It is perhaps not unnatural that opticians should have hesitated in giving their confidence to so decided a departure from established usage, especially as there may have been reason for apprehending practical difficulties in working surfaces to correspond with the new curves. Yet these difficulties have certainly now been overcome, at least for lenses of moderate dimensions, and it is understood that the Messrs. Steinheil are prepared to apply the system to object-glasses of the largest size for which suitable material can be procured.

The chief advantage proposed to be gained is the more complete removal of the indistinctness caused by the dispersion of the rays of different colors, without sensibly increasing the influence of spherical aberration even when the ratio of the aperture to the focal length is considerably increased above its usual proportion. In the opinion of competent judges, the trials which have thus far been made of telescopes of the new construction have exhibited a decided superiority as respects clearness of definition with large angles of aperture, thus confirming in the most satisfactory manner the correctness of the principles upon which Gauss has based his theory. Steinheil's notices of the new object glasses are in the *Sitzungsberichte der k. bayer Akad. der Wiss., München*, 1860, Heft. ii, and v.

Book Notices.—

1. *Storer's Dictionary of the Solubilities of Chemical Substances.* Part II, pp. 233–456.—This part brings the subject down to near the close of the oxyds, ending with Protoxyd of tin. The work is done in the same style of conscientious fidelity and with the same evidence of erudition which characterized the first part. Confirming all we had occasion to say on the appearance of Part I ([2], xxxv, 303), we congratulate the author upon the prospect of completing his "First Outlines" with another half year, a work which, however irksome in its performance, is a most substantial contribution to science and an enduring monument of the author's industry and learning.

2. *Practical Treatise on Limes, Hydraulic Cements and Mortars*, containing reports of numerous experiments conducted in New York City, 1858 to 1861; by Quincy A. Gilmore, A.M., Brig. General U. S. Volunteers, and Major U. S. Corps of Engineers. New York: D. Van Nos-

trand, 192 Broadway, 1863. 8vo. pp. 333.—General Gilmore's treatise is number nine of a series of "Papers on Practical Engineering" issued from the U. S. Engineer Department. It is admirable for its lucid method, its clearness and exactness of statement, and the amount of original matter it embraces on a subject of the greatest practical importance. For the first time we have here presented a full account of the various American building materials embraced under the three heads considered. They are considered in their geological relations, their geographical distribution, mode of manufacture, chemical constitution before and after preparation, and especially in their economical value. This last has been tested by carefully conducted experiments upon the tenacity, hardness and power of endurance of atmospheric and subaqueous changes, the results of which trials are presented in condensed tables. Many of the more important qualities of hydraulic cements are presented by diagrams in the form of curves projected in such a manner as to present to the eye the comparison between various samples, more prominently than a written description could do. The volume is prepared in the best mechanical style. The pressing public duties of the distinguished author before Charleston have prevented his careful revision of the sheets, although the typography is remarkably correct. A few slips of this sort will be easily corrected in a second edition.

OBITUARY.

STILLMAN MASTERMAN.—It is with pain that we record the early decease of our contributor Stillman Masterman, of Weld, (Maine,) who died of pulmonary consumption in that town on the 19th July, at the age of 32 years.

From an interesting and touching account of his life written by himself during his last moments, and with a perusal of which we have been favored, we learn the prominent incidents of his life. It has been simply a new version of the old, yet always new, story. It has shown a pure and aspiring spirit, athirst for knowledge, and yearning to take part in the enlargement of its bounds,—a mind formed for thorough investigation, and exalted above all local discouragements and the sneers of ignorance,—an enthusiasm, rising almost to devotion, for Nature in her grandest and most majestic manifestations,—a character full of all delicacy, modesty, and native refinement; but with all these gifts, which, if accompanied by a sturdier physical frame and aided by larger advantages in youth, would have surely led to high eminence in science, restricted by circumstances over which he had no control until it was too late.

Such an earnest, truthful, follower of science, Masterman truly was. None who met him could fail to note the almost feminine delicacy of his moral nature, and the careful observer soon remarked that the reserve of his manner sprang from modesty and not from coldness.

He was born in Weld, a village in Franklin Co., Maine, just at the base of Mt. Blue,—on the 28th of January, 1831. His first attendance at the district school was at a rather later age than usual, and he has vividly described the sensations which were awakened in him, when, in his eleventh year, an elementary geography was first put into his hands, and for the first time he learned the form of the earth and the primary facts

of physical geography. From this time on, he seized and drained every old book which he could find containing information on any branch of physical science, and laid aside such sums of money as came into his possession until he had accumulated the means of purchasing new books on these subjects. These he studied with ardor. "Frequently," he writes, "I carried books into the field when I went out to labor, to peruse while resting from toil;—some shady tree serving as my school room, and a few moments of study serving to give me a subject for frequent rehearsals during an hour's toil."

At the age of twenty, he had managed to collect a number of scientific and classical works and had thus become familiar with the elements of physics and chemistry,—making such apparatus as the materials at hand would permit, grinding and polishing small lenses and constructing prisms for experiments on fluid media. He had also taught himself Latin enough to read with some ease, and had become familiar with algebra, geometry and trigonometry. At this period he went to the newly opened territory of Minnesota to seek his fortune in the far West; but after a little more than a year he returned to his native place, with health much impaired by the influence of that climate.

His first publication of which I am aware was a paper entitled, "Observations on Thunder and Lightning" printed in the Appendix to the Tenth (1855) Annual Report of the Regents of the Smithsonian Institution. In this he gave an interesting series of results of observations of sixteen thunder-storms during the years 1850–4 at Weld, and at Stillwater (Minn.) For each of these storms he had noted the character and the intervals of phase for the different thunder-peals,—and to these observations added the record of other curious allied phenomena. The summary shows the average length of the thunder-peal to have been $21^s{\cdot}85$ in the 148 observed instances when preceded by visible lightning, and $26^s{\cdot}60$ in the 156 cases when not so preceded. The minimum interval which he had recorded between the flash and report was 1^s; the maximum, 56^s. A very full account is given of a severe thunder-storm, 1854, June 15; and an authentic instance is afforded of the occurrence of thunder in a cloudless sky,—which he succeeded in tracing to its origin in a storm below the eastern horizon.

Mr. Masterman subsequently became a frequent contributor to this and other scientific journals. Without instruments, he devoted himself earnestly and faithfully to the observation of such celestial phenomena as could be sufficiently noted by the naked eye, and his observations of maxima and minima of variable stars as well as of the zodiacal light, auroras, meteors, the brilliancy of planets, &c., &c., are surpassed in accuracy by none made under similar circumstances. Among his writings are the following,—the list being, however, probably incomplete.

Smithsonian Reports, 1855, pp. 265–282; 1857, 323–332.

Amer. Jour. of Science, [2], xxx, 155; xxxv, 149, 50; xxxvi 143–5.

Astron. Journal, v, 31, 37, 105, 140, 191; vi, 38, 44, 47, 83, 85, 96, 183, 187.

During the last two years, until his failing health compelled him to desist from all labor, Mr. Masterman was engaged upon the reduction of observations made at the Washington Observatory during the fifteen

years previous to the defection of the late Superintendent, and subsequently found unreduced. In this, as in all his other labors, his efforts were marked by ability and success.

He died, as he had lived, a Christian and a philosopher, resigned to the will of God, and in full peace of mind. B. A. G.

MAJOR EDWARD B. HUNT.—The death of Major Hunt of the U. S. Topographical Engineers, by an unhappy accident while in discharge of his duties, has occasioned universal regret and sadness wherever this gifted and excellent officer was known. To science his loss is great. In the very prime of life and power, he had already added many important contributions to our stock of physical knowledge, and at the time of his death had been engaged for many months in elaborating his novel ideas upon the subject of Molecular Physics, some outlines of which he had already presented at one of the Sessions of the Connecticut Academy of Arts and Sciences in the Spring of this year.

Major Hunt was appointed a cadet in the U. S. Military Academy at West Point, from New York, in 1841, and was graduated in July, 1845, as Second Lieutenant of Engineers. He discharged the duties of Assistant Professor of Engineering at the Military Academy from 1846 to 1849. It was during this period that he first became a contributor to the pages of this Journal, his earliest paper "On the dispersion of light," appearing in volume vii, p. 364, and from that time he was a frequent contributor on various physical subjects, his papers being always marked by originality and power of generalization. The volumes of Proceedings of the American Association also contain numerous papers from his pen. One of his latest productions, *Union Foundations*, is an attempt to show the physical reasons for American national unity, a very readable and ingenious paper, the product of a glowing patriotism. We should add to these his proper professional papers on Engineering topics.

For some two years past Major Hunt had been engaged under a special commission in perfecting a submarine battery of his own invention, the details of which are very properly kept secret. He had just completed this apparatus and perfected his system, and on the 1st of October was engaged in making a final experiment on board a vessel some five miles from Brooklyn Navy Yard. The gun (a breech loader) had been fired in the submerged cell, when, from an unwonted escape of smoke in the vessel, Major Hunt who was on deck with his men, was induced to go below to ascertain what the difficulty was, and there was suffocated by the irrespirable gases; he succeeded in partly ascending to the companion way, and extended a hand as a signal for relief. An attendant seized the hand; but at the same instant exhaustion caused him to fall into the hold where he lay with his face in a pool of water. One of the men descended instantly to his relief, but succeeded only in raising his head out of the water, when in turn overcome by the foul gases, he was compelled to seek safety by escape from the apartment. Another man partially succeeded in securing a rope to the fallen officer, but, sad to relate, in the effort to raise him the fastening gave way, and he fell heavily a second time, producing, as is supposed, concussion of the brain. He was not extricated until, by throwing down water, the atmosphere was so far renewed as to render it possible to go into the hold, and it was some

hours before surgical aid could be obtained, owing to their distance from shore, when it was alas! too late. He died soon afterwards, and, as a soldier should, in the service of his country, not, indeed, on the battlefield, but with his armor on, and while engaged in perfecting a most important application of scientific principles to defensive war.

His funeral was celebrated with military honors at West Point Military Academy on Monday, October 5th, where he sleeps in the Military Cemetery amid the honored remains of many companions-in-arms, who have fallen on various fields in their country's service, or while engaged in the more peaceful duties of their profession.

Major Hunt was about 40 years of age at the time of his death. He leaves a widow and one son. A fuller notice of his life and labors will appear in a future issue of this Journal. The Connecticut Academy sent Prof. Alex. C. Twining as a delegate to represent them and the men of science in Connecticut at the funeral, and from the report of this delegation, submitted at the last session of the Academy, we have drawn some of the details of Major Hunt's tragical death.

Prof. EILHARD MITSCHERLICH.—Prof. Mitscherlich has recently died at Berlin at the age of sixty-nine. He had long been known as one of the ablest philosophical chemists of the day, and the estimation in which he was held was exemplified by the numbers who attended his classes in the University of Berlin, and the Friedrich-Wilhelm's-Institut in that city. The mere titles of his writings would occupy nearly two columns of this journal; they embrace a wide range in chemical science, and may be found in the publications of the Academy of Sciences of Berlin, of which he was a member, and in German periodicals. Besides these, he was the author of a 'Lehrbuch der Chemie,' in two volumes, which has passed through two editions, and has been translated into French. Dr. Mitscherlich was elected a Foreign Member of the Royal Society in 1828; and in 1829 one of the Royal Medals was awarded to him for his 'Discoveries relating to the Laws of Crystallization and the Properties of Crystals.' It is, perhaps, by his researches into the phenomena of dimorphism that he will be best remembered.—*Athenæum*, No. 1876, p. 470.

PROC. OF THE AM. ACAD. OF ARTS AND SCIENCES, (continued from vol. XXXV) Vol. V, from May, 1860 to May, 1862.—314, Notes upon a portion of Dr. Seeman's recent collection of dried Plants gathered in the Feejee Islands; *Asa Gray.*—321, Characters of new or obscure species of Plants of Monopetalous Orders in the Collection of the United States South Pacific Exploring Expedition under Capt. Charles Wilkes, U.S.N., with occasional remarks, &c.; *Asa Gray.*—353, Abstract of a Memoir upon the Attraction of Saturn's Ring; *Prof. Peirce.*—355, On the double salts of cyanid of Mercury; *Wm. P. Dexter.*—359, Remarks upon the recent determinations of the Atomic Weight of Antimony; *W. P. Dexter.*—370, Criticism on a recent work by Capt. Rodman, U.S.A., on improvements in heavy ordnance; *Prof. Treadwell.*—379, Upon the System of Saturn; *Prof. Peirce.*—383, Observations on North American and other Lichens; *Edward Tuckerman, A.M.* (continued from vol. iv, p. 407.)

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA, from January to July, 1863.—2, Descriptions of Fossils from the Yellow Sandstone lying beneath the "Burlington Limestone," at Burlington, Iowa; *Alexander Winchell.*—25, Catalogue of the North American Sciænoid Fishes; *Theodore Gill.*—33, Systematic arrangement of the Mollusks of the Family Viviparidæ and others, inhabiting the United States; *Theodore Gill.*—40, Additional Remarks on the North American Ægiothi; *Elliott Coues, A.M., M.D.*—43, On Trachycephalus, Scaphiopus and other American Batrachia; *E. D. Cope.*—55, Enumeration of the Species of

Plants collected by Dr. C. C. Parry, and Messrs. Elihu Hall and J. P. Harbour, during the Summer and Autumn of 1862, on and near the Rocky Mountains, in Colorado Territory, lat. 39°-41°; *Asa Gray.*—80, Catalogue of the Fishes of Lower California, in the Smithsonian Institution, collected by Mr. J. Xantus; *Theodore Gill*—88, Description of some new species of Pediculati, and on the classification of the group; *Theodore Gill.*—93, Enumeration of the Arctic Plants collected by Dr. I. I. Hayes in his Exploration of Smith's Sound, between parallels 78th and 82d, during the months of July, August and beginning of September, 1861; *E. Durand, Thos. P. James and Saml. Ashmead.*—96, Additions to the Catalogue of Stars which have changed their colors; *Jacob Ennis.*—100, Descriptions of new American Squamata, in the Museum of the Smithsonian Institution, Washington; *E. D. Cope.*—106, Descriptions of new species of Birds of the Families Vireonidæ and Rallidæ; *Geo. N. Lawrence.*—107, Descriptions of new Species of North American Pedipalpi; *H. C. Wood, Jr.*—113, On a Third Kingdom of Organized Beings; *Thomas B. Wilson, M.D.*, and *John Cassin.*—121, On the Lestris Richardsoni of Swainson; with a Critical Review of the Subfamily Lestridinæ; *Elliott Coues, M.D., U. S. A.*—138, Synopsis of the Marine Invertebrata collected by the late Arctic Expedition under Dr. I. I. Hayes; *Wm. Stimpson. M.D.*—143, Contributions towards a Monography of the order of Pholadacea, with descriptions of new Species.—No. 2; *George W. Tryon, Jr.*—146, Descriptions of two new species of Fresh Water Mollusca, from Panama: Description of a new Exotic Melania; *George W. Tryon, Jr.*—147, Descriptions of new Species of Fresh Water Mollusca, belonging to the Families Amnicolidæ, Valvatidæ and Limnæidæ, inhabiting California; *George W. Tryon, Jr.*—150, Notes on the Birds of Jamaica; *W. T. March.*—154, Descriptions of fourteen new Species of Melanidæ and one Paludina; *Isaac Lea.*—157, Descriptions of four new species of Spermophilus, in the collections of the Smithsonian Institution; *Robert Kennicott.*—159, Additions to the Catalogue of Stars which have changed their colors; *Jacob Ennis.*—162, Descriptive enumeration of a collection of Fishes from the Western coast of Central America, presented to the Smithsonian Institution, by Capt. John M. Dow; *Theodore Gill.*—174, Enumeration of the Fish described and figured by Parra, scientifically named by Felipe Poey; translated and edited by *J. C. Brevoort.*—180, Descriptions des Poissons nouvelles ou peu connues; *M. Felipe Poey.*—189, Descriptions of eleven new species of Exotic Unionidæ; *Isaac Lea.*—190, Description of a new species of Unio and a Monocondylœa; *Isaac Lea.*—191, Descriptions of twenty-four new species of Unionidæ of the United States; *Isaac Lea.*—194, Notes on the Picidæ, with descriptions of new and little known species; *John Cassin.*

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